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## **A multimodal investigation of targeted treatment approaches for eating disorders**

Turton, Robert John

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# **A multimodal investigation of targeted treatment approaches for eating disorders**

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Robert Turton

Institute of Psychiatry, Psychology & Neuroscience

King's College London

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Thesis submitted to King's College London for the  
degree of Doctor of Philosophy (PhD)

2017

## Abstract

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Significant progress has been made in the past few decades in understanding how to effectively treat eating disorders. However, there remain unanswered questions and limitations in the evidence-base. To enhance treatment outcomes further, a more targeted approach to key underlying cognitive maintenance factors may be beneficial. The aims of this thesis are as follows: (1) to build an accurate profile of the mechanisms underpinning eating disorder psychopathology; and (2) to consider approaches to modify these processes. Specifically, this thesis will focus on the use of two computerised cognitive training paradigms among people with eating disorders: Cognitive Bias Modification (CBM), and food-specific inhibition training.

The first section of the thesis focuses on interpersonal difficulties, examining whether women with Anorexia Nervosa (AN) have a negative interpretation bias for social stimuli in comparison to healthy women. Experimental studies were then conducted to examine the effectiveness of a single session of CBM in targeting a negative interpretation bias in women and adolescents with AN. The next part of the thesis focuses on mapping the factors underlying binge-type eating disorders. This includes two reviews, and a proof of concept study of food-specific inhibitory control training for women with Bulimia Nervosa (BN) and Binge Eating Disorder (BED).

The findings of this thesis highlight novel targets for the treatment of eating and weight disorders, across different age ranges and treatment settings. The findings suggest that cognitive training paradigms are acceptable for people with these illnesses, and that a single session of training produces small to moderate effects on the processes that it is aiming to modify. Further research investigating the effect of multiple sessions of cognitive training on core symptomatology, employing longer-term follow-ups and larger sample sizes, would be the next stage in the development and evaluation of new treatment enhancers for people with eating disorders.

## Acknowledgments

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First of all I would like to express my gratitude to Professor Janet Treasure for her continuous inspiration, guidance, and expertise in helping me to complete this project. You have taught me the true meaning of collaboration. Dr Colette Hirsch, thank you for supporting me throughout the course of my PhD, you have helped me to become a better scientist. Similarly, Dr Valentina Cardi, your knowledge, advice, and friendship have been invaluable. I would also like to thank Dr Natalia Lawrence for all of her guidance, kindness, and help.

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My friends in the basement have taught me so much both personally and professionally and are the reason that I have made it to the end of my PhD. I could not imagine my experience without you. Thank you, Gaia Albano, Rayane Chami, Katie Rowlands, Viviana Aya, Jenni Leppanen, Monica Leslie, Dr Charlotte Rhind, Dr Núria Mallorquí, and Dr Alessio Monteleone.

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I would like to thank all of my friends from my hometown, university and London. Josh Lindo, Frazer Lewis, Nicola Caiquo, Matt Radburn, and Sam Knight, you have always been there for me and supported me in so many ways.



I am so grateful to all of the people that participated in this project for their commitment and kindness. I also want to thank the hospital sites for helping me to recruit, namely, the Bethlem Royal Hospital, St Ann's Hospital, Ellern Mede, Vincent Square Eating Disorder Service, and King's College Hospital. Thank you to all of the clinicians, researchers, and team members that contributed towards this, in particular Zoe Vazquez-Sanchez for always making me feel so welcomed.

Most of all I want to thank my family for their love and support throughout my PhD. You have always listened and given me encouragement when I have had doubts. I would like to dedicate this thesis to the memory of Micheala Christoforou and Professor Bryan Lask. I learnt so much from your resilience, passion, and humour; I had you in mind throughout my PhD.

## **Financial acknowledgements**

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## **List of abbreviations**

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**ADHD** – Attention Deficit/ Hyperactivity Disorder

**AN** – Anorexia Nervosa

**APA** – American Psychological Association

**ARS-Q** – Adult Rejection Sensitivity - Questionnaire

**BED** – Binge Eating Disorder

**BMI** – Body Mass Index

**BN** – Bulimia Nervosa

**CBM-I** – Cognitive Bias Modification - Interpretations

**CBT** – Cognitive Behavioural Therapy

**CI** – Confidence Interval

**DSM** – Diagnostic and Statistical Manual of Mental Disorders

**FREED** - First episode and Rapid Early intervention for Eating Disorders

**ICD** – International Classification of Diseases

**IQR** – Inter Quartile Range

**M** - Mean

**Mdn** - Median

**MRC** – Medical Research Council

**NICE** – National Institute of Clinical Excellence

**NHS** – National Health Service

**OCD** – Obsessive Compulsive Disorder

**OFC** – Orbitofrontal cortex

**OSFED** – Other Specified Feeding and Eating Disorder

**RDoC** – Research Domain Criteria

**SCID** – Structured Clinical Interview for the Diagnostic and Statistical Manual of Mental Disorders

**SD** – Standard Deviation

**SMC** – Standardised Mean Change

**SPSS** – Statistical Package for the Social Sciences

**STATA** – Statistics and data package

**VAS** – Visual Analogue Scale

**WSAS** – Work and Social Adjustment Scale

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### Publications included within the thesis

Treasure, J., Cardi, V., Leppanen, J., & **Turton, R.** (2015). New treatment approaches for severe and enduring eating disorders, *Physiology & Behavior*, 152, 456-465. doi: 10.1016/j.physbeh.2015.06.007.

Cardi, V., **Turton, R\***, Schifano, S., & Leppanen, J., Hirsch, C., & Treasure, J. (2017). Biased interpretation of ambiguous social scenarios in anorexia nervosa, *European Eating Disorders Review*, 25, 60-64. doi:10.1002/erv.2493.

**Turton, R.**, Cardi, V., Treasure, J., & Hirsch, C. (2018). Modifying a negative interpretation bias for social scenarios that depict the risk of rejection in women with anorexia nervosa, *Journal of Affective Disorders*, 227, 705-712. doi: 10.1016/j.jad.2017.11.089.

**Turton, R\***, Chami, R., & Treasure, J. (2017). Emotional eating, binge-eating and animal models of binge-type eating disorders, *Current Obesity Reports*, 6 (2), 217-228. doi: 10.1007/s13679-017-0265-8.

**Turton, R.**, Bruidegom, K., Cardi, V., Hirsch, C., & Treasure, J. (2016). Novel methods to help develop healthier eating habits for eating and weight disorders: A systematic review and meta-analysis, *Neuroscience & Biobehavioral Reviews*, 61, 132-155. doi: 10.1016/j.neubiorev.2015.12.008.

**Turton, R.**, Nazar, B., Burgess, E., Lawrence, N., Treasure, J., & Hirsch, C. (2018). To go or not to go: A proof of concept study testing food-specific inhibition training for women with eating and weight disorders, *European Eating Disorders Review*, 26 (1), 11-21. doi: 10.1002/erv.2566.

## Other publications

**Turton, R.**, Goodwin, H., & Meyer, C. (2017). Athletic identity, compulsive exercise and eating psychopathology in long-distance runners, *Eating Behaviors*, 26, 129-132. doi: 10.1016/j.eatbeh.2017.03.001.

Giombini, L., **Turton, R\***, Turco, M., Nesbitt, S., & Lask, B. (2016). The use of cognitive remediation therapy on a child and adolescent eating disorder unit: Patients and therapists perspectives, *Clinical Child Psychiatry & Psychology*. pii: 1359104516657859.

**\* Joint first author**

## Presentations associated with the thesis

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### Oral presentations:

To go or not to go: Food-specific inhibition training in eating disorders. Presented at the Eating Disorders Research Society, New York, 2016.

Novel methods to help develop healthier eating habits for eating and weight disorders: A systematic review and meta-analysis. Eating Disorders International Conference, London, 2016.

Reflections on taking part in the Self-Help and Recovery guide for Eating Disorders (SHARED) project. National Carers Conference for Eating Disorders, London, 2015.

**Poster presentations:**

To go or not to go: Food-specific inhibition training for bulimia nervosa. International Conference on Eating Disorders, Prague, 2017; Eating Disorders Research Society, New York, 2016; the British Association for Psychopharmacology. Brighton, 2016; Eating Disorders International Conference, London, 2016.

Novel methods to help develop healthier eating habits for eating and weight disorders: A systematic review and meta-analysis. Advances in the Science of Habits, Los Angeles, 2017; Association for the Study of Obesity, London, 2015; PhD student symposium, King's College London, 2015.

Dysfunctional reward processes in eating disorders: The role of food 'liking' and 'wanting'. Association for the Study of Obesity, London, 2015.

**Workshops:**

The systematic implementation of Cognitive Remediation Therapy (CRT) in an eating disorders inpatient unit. Lucia Giombini, Matteo Turco, & Robert Turton. London International Eating Disorders Conference 2015.

**Published conference papers:**

Dysfunctional reward processes in eating disorders: the role of food 'liking' and 'wanting'. *Appetite*, 2015.

Novel methods to help develop healthier eating habits for eating and weight disorders: A systematic review and meta-analysis. *Appetite*, 2015.

To go or not to go: Brain training in eating and weight disorders. *European Eating Disorders Review*, 2016.

## Declaration of candidate's role

---

### **Chapters one and two: An overview of eating disorders and new treatment approaches**

These chapters are based upon a publication written by the candidate, Janet Treasure (J.T.), Valentina Cardi (V.C.), and Jenni Leppanen (J.L.). The candidate was the senior and corresponding author on the paper. Each of the authors contributed to the writing and intellectual content of the publication. The candidate expanded upon this publication for the introduction of this thesis by providing a more in depth overview of eating disorders and the rationale for the thesis.

### **Chapter three: Biased interpretation of ambiguous social stimuli in AN**

V.C., Colette Hirsch (C.H.), and J.T. designed this study, and were involved in the writing of the publication. The candidate was a joint first author on the publication with V.C., and carried out the data analysis and contributed to the writing of the publication. Sylvia Schifano (S.S), and Jenni Leppanen (J.L.) completed the recruitment and were the independent raters for the sentence completion task.

### **Chapter four: Modifying a negative interpretation bias for social stimuli in women with AN**

The candidate, J.T., C.H., and V.C., designed this study and contributed to the intellectual content of it. The NHS ethics application, recruitment, stimulus creation and testing was completed by the candidate. A research assistant also gave some assistance with recruitment (Lavinia Thelan). The candidate had a primary role in doing the data analysis and writing the manuscript for publication. All of the authors provided comments on the manuscript.

## **Chapter five: Cognitive bias modification for negative interpretations of social stimuli in adolescents with AN**

The candidate, J.T., C.H., V.C., and Charlie Brazil (C.B.) were involved in the design of this study. Further, the candidate completed the NHS ethics application for the project and; completed the stimulus creation. Along with Amy Harrison (A.H.), the candidate supervised C.B. to complete a Masters project looking at a preliminary analysis of the data from 15 participants involved in the project. C.B. completed all of the recruitment for this study at Ellern Mede eating disorders service with some assistance from Louise Gregor (L.G.). The candidate completed the data analysis and supported C.B. in preparing a Master's dissertation and manuscript based on the data collected. The candidate made a substantial contribution to the writing of the manuscript and completed the data analysis.

## **Chapter six: Emotional eating, binge eating and animal models of binge-type eating disorders**

The candidate is a joint first author on this publication with Rayane Chami (R.C.). This involved making a substantial contribution to the writing of the manuscript, its preparation, submission and revisions. J.T. supervised the preparation of the publication and contributed to the intellectual content and writing of it.

## **Chapter seven: Novel methods to help develop healthier eating habits for eating and weight disorders: a systematic review and meta-analysis**

The candidate is the first and corresponding author for this publication. The candidate, Kiki Bruidegom (K.B.), and J.T. were involved in the design of the study. K.B. devised the search terms and completed the search of the databases for relevant articles. The candidate and K.B. supervised two research assistants (Faisal Jamshaid and Danielle Wilcock), who helped to extract data from the articles. The candidate and K.B. completed the meta-analyses. The candidate was the primary contributor to the writing of the publication and its revisions following peer review, with comments from all of the authors (K.B., V.C., C.H., and J.T.).

## **Chapter eight: To go or not to go: A proof of concept study testing food-specific inhibition training for women with eating and weight disorders**

The candidate, Janet Treasure (JT), Colette Hirsch (CH), Natalia Lawrence (NL), and Bruno Nazar (BN) contributed to conception and design of the study. The candidate completed the NHS ethics application for the project, and with the help of BN and Emilee Burgess (EB), completed the recruitment, screening and testing of participants. The candidate had the primary role in completing the data analysis and writing of the publication. All of the authors made comments and helped to prepare the manuscript for publication.

## **Chapter nine: General discussion**

All work is the candidates own.

**Signature:**



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**Date:**

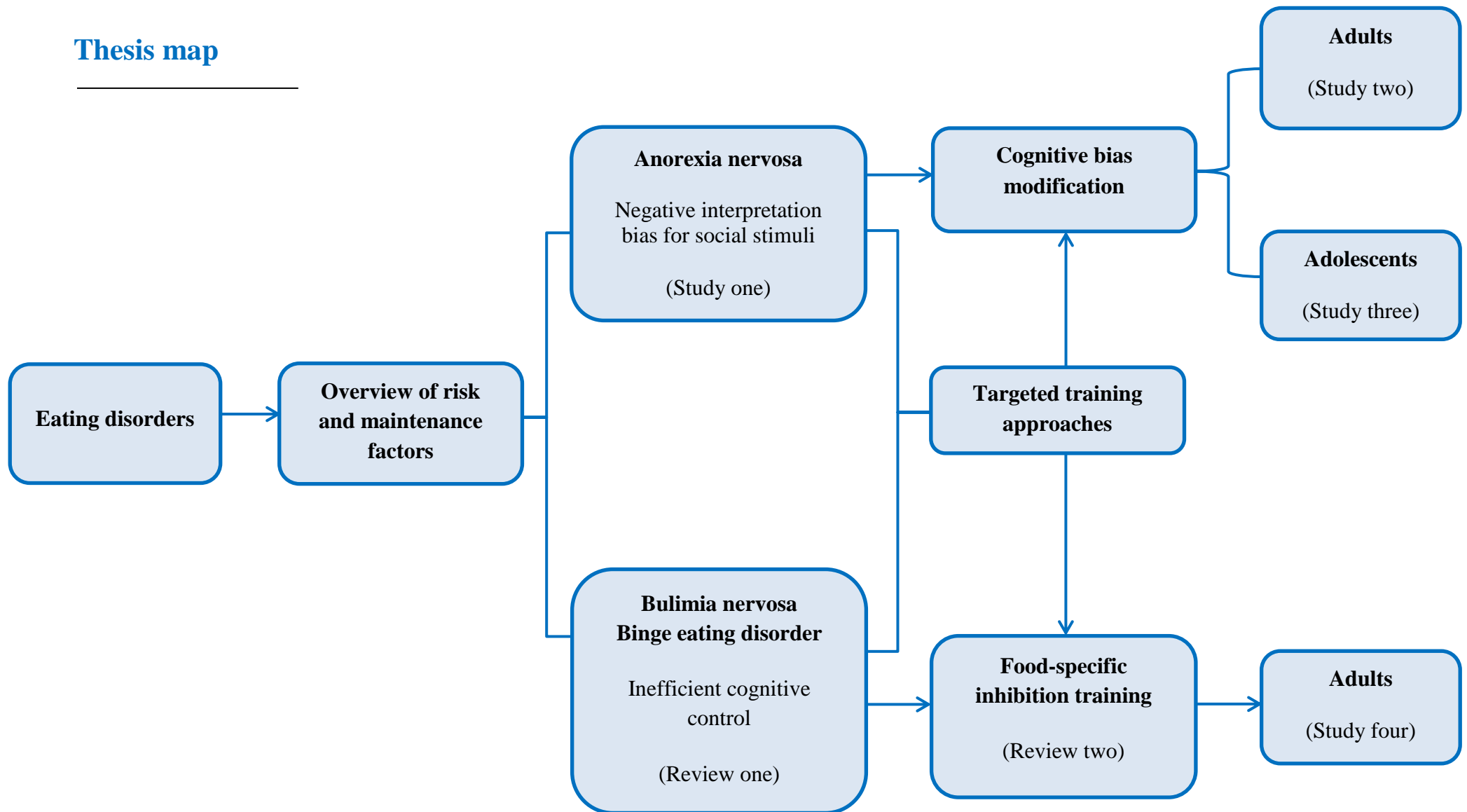
24.03.2018

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## Thesis map

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## An overview of eating disorders

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**Based upon the following publication:**

Treasure, J., Cardi, V., Leppanen, J., & **Turton, R.** (2015). New treatment approaches for severe and enduring eating disorders, *Physiology & Behavior*, 152, 456-465. doi: 10.1016/j.physbeh.2015.06.007.

## **1.1. Chapter aims**

The aim of this introductory chapter is to provide an overview of eating disorders and to provide the context for this thesis. It will begin by considering the nature of eating disorders, their classification, epidemiology, and co-morbidity with other mental illnesses. A summary of risk and maintenance models of eating disorders that are particularly relevant to this thesis will be described. The next section of this chapter reviews the latest guidelines and findings regarding the treatment of eating disorders. It will be suggested that although significant advances have been made in the treatment of eating disorders, currently there are limitations and unanswered questions relating to the evidence base. Therefore, new approaches may be needed to improve treatment outcomes further.

## **1.2. The characteristics of eating disorders**

### **1.2.1. Overview**

Eating disorders have been described as being amongst the most difficult mental health problems to treat (Fairburn et al., 2013; Halmi et al., 2005). This is because these highly distressing conditions often run a protracted course (e.g., Fichter, Quadflieg, Crosby, & Koch, 2017; Wentz, Gillberg, Anckarsater, Gillberg, & Rastam, 2009). Moreover, they are associated with high mortality and suicide rates (Arcelus, Mitchell, Wales, & Nielsen, 2011; Crow et al., 2009). A recent survey by a national eating disorders charity called B-eat (B-eat, 2015) found that eating disorders are highly detrimental to the quality of life, social and family life, education, and careers of both people with eating disorders and their carers. However, despite all of these damaging consequences, recovery from an eating disorder is possible even in individuals with long illness durations (Eddy et al., 2017).

### **1.2.2. The diagnostic classification of eating disorders**

The Diagnostic and Statistical Manual of Mental Disorders-fifth edition (DSM-5; APA, 2013) criteria for Anorexia Nervosa (AN) include significant weight loss (i.e., relative to an individual's sex, age and developmental trajectory), and an acute sense of fear associated with increasing weight. People may be diagnosed as having atypical AN if they are not underweight but meet the other diagnostic criteria for AN. The criteria for Bulimia Nervosa (BN) comprise the presentation of binge eating (i.e., eating large amounts of food during a two-hour period associated with a sense of loss of control), and compensatory behaviours (e.g., self-induced vomiting and laxative abuse) at least once a week for three months. For both AN and BN, self-evaluation is excessively influenced by body weight and shape.

Regarding Binge Eating Disorder (BED), the DSM-5 criteria include the presence of binge-eating episodes at least once a week for three months. These binge-eating episodes must be associated with three or more of the following criteria: (1) eating more quickly than usual; (2) eating until feeling excessively full; (3) overeating occurs even when not physically hungry; (4) eating alone because of shame relating to eating; and (5) feeling very guilty after eating binges. The person must also report that these binge-eating episodes are highly distressing and that they are not followed by excessive and recurrent compensatory behaviours. People may be diagnosed as having an Other Specified Feeding or Eating Disorder (OSFED) if they experience binge-eating/ purging episodes but at a lower frequency than the DSM-5 criteria for BN and BED. Other OSFED diagnoses include avoidant/ restrictive food intake disorder, purging disorder, and the aforementioned diagnosis of atypical AN.

### **1.2.3. The epidemiology of eating disorders**

Eating disorders typically develop during adolescence in females. However, they can occur at any age and in males (e.g., Strother, Lemberg, Stanford, & Turberville, 2012). It has been reported that up to 0.3% of females might develop AN, 1% BN, and 1.4% BED across the lifespan (Hoek, 2006; Hoek & van Hoeken, 2003; Kessler, 2013). For males a similar

trend in the proportion of each eating disorder is reported. However, prevalence rates are lower than for females with 0.3-0.7% of males reporting current presentation of an eating disorder (Keski-Rahkonen, & Mustelin, 2016; Strother et al. 2012).

Literature reviews have indicated incidence rates of 8 cases of AN, and 12 cases of BN, per 100,000 members of the population per year (Hoek, 2006; Hoek & van Hoeken, 2003). Regarding BED, there has been a relative dearth of incidence studies (Striegel-Moore, & Franko, 2003). A recent study in Finland by Mustelin, Raevuori, Hoek, Kaprio and Keski-Rahkonen (2015) reported an incidence rate of 35 cases of BED, amongst women age 10-24, per 100,000 members of the population per year. Of note, only 6% of the sample presenting with BED had received a diagnosis from a healthcare professional prior to the study highlighting that a majority of people with this illness are not receiving treatment.

#### **1.2.4. “Comorbidity is the rule rather than the exception for patients with eating disorders”**

– Treasure, Claudino, and Zucker (2010)

A host of clinical conditions often present co-morbidly with eating disorders including, but not limited to, anxiety disorders (e.g., Kaye, Bulik, Thornton, Barbarich, & Masters, 2004), depression (e.g., Grilo, & Becker, 2016), substance use disorders (e.g., Blinder, Cumella, & Sanathara, 2006), personality disorders (Schmidt, & Telch, 1990), autism spectrum disorder (e.g., Rhind et al., 2014; Westwood, Mandy, & Tchanturia, 2017), attention-deficit/ hyperactivity disorder (e.g., Nazar et al., 2016), and obsessive-compulsive and related disorders (Cederlöf et al., 2015). These comorbidities may increase the clinical complexity of eating disorders and contribute to a loss of treatment responsivity (Treasure, Stein, & Maguire, 2015). Therefore, increasingly researchers have called for more transdiagnostic treatment approaches for mental health problems, which may be targeted at common maintaining factors (e.g., Fairburn, Cooper, & Shafran, 2003; McEvoy, Nathan, & Norton, 2009).

### **1.3. Risk and maintenance models of eating disorders**

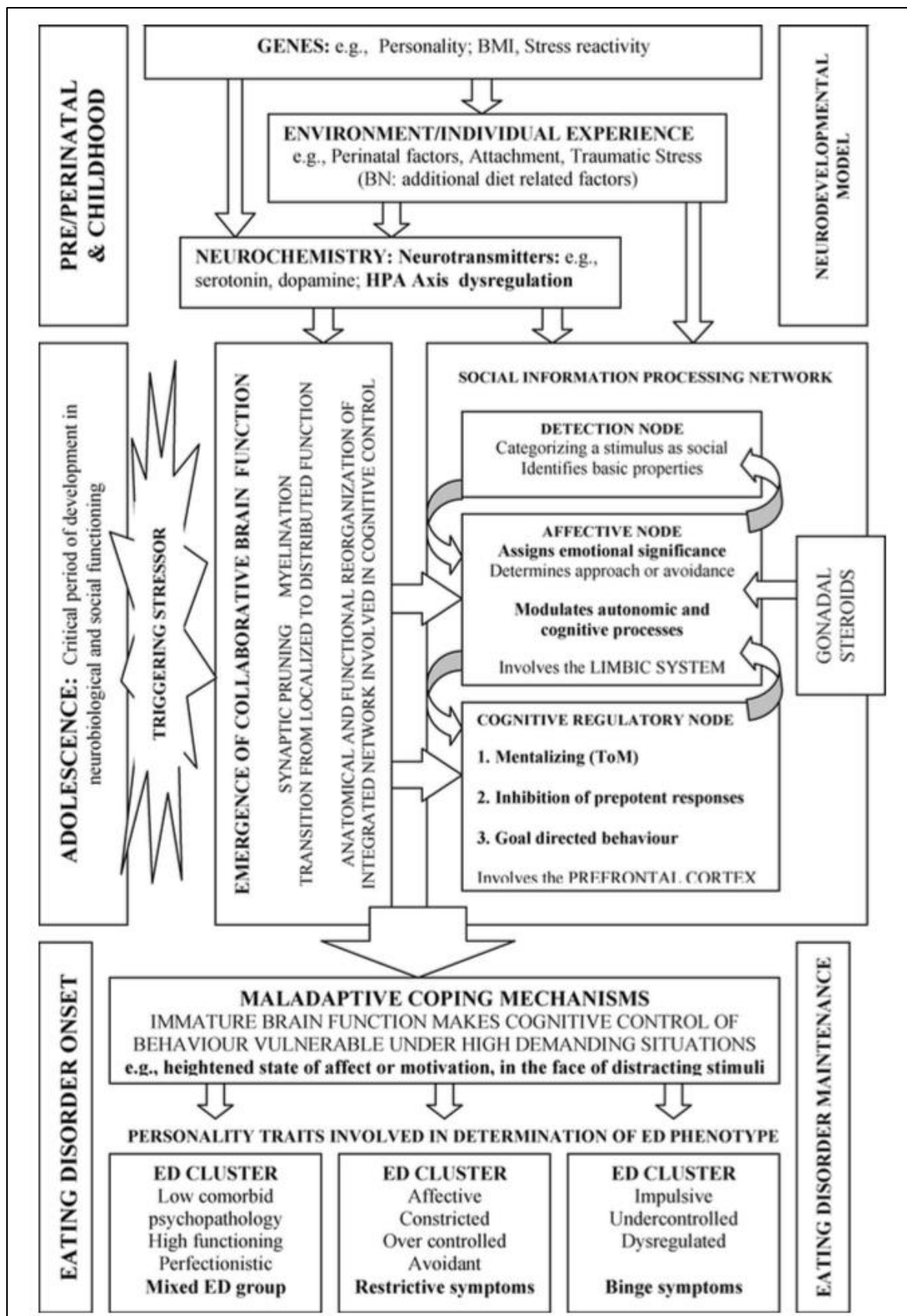
#### 1.3.1. A transdiagnostic model of eating disorders (Fairburn, Cooper, & Shafran, 2003)

This cognitive-behavioural model of eating disorders postulates that there are shared maintenance mechanisms across AN, BN and atypical eating disorders. It suggests that a primary transdiagnostic concept across all of these illnesses is the over-evaluation of weight and shape (i.e., extreme importance is given to weight and shape in defining the value of the self). This leads people to adopt very strict diets and other weight control behaviours, such as compulsively exercising, in order to control their weight. This dietary restriction can increase the risk of binge-eating episodes as the breaking of rigid dietary rules can cause a negative reaction in which people temporarily lose control over their eating. In response to this episode of over eating they may then engage in purging behaviours, such as self-induced vomiting, to prevent weight gain. Additionally, people may have difficulties in interpersonal relationships, clinical perfectionism, mood intolerance and core low self-esteem, which can underpin psychopathology.

Support for this transdiagnostic model is partly ascertained from the high rates of cross-over between the different eating disorder diagnoses (e.g., Fairburn, & Harrison, 2003). However, a potential limitation of this model is that it focuses quite broadly on the factors that might maintain eating disorders (e.g., interpersonal relationships) as opposed to specific underpinning mechanisms (e.g., a fear of negative evaluation, rejection sensitivity). Furthermore, this model may not fully account for the neurobiological processes that may maintain eating disorder symptoms (Treasure, Leslie, Chami, Fernandez-Aranda, 2018).

### 1.3.2. A socio-cognitive model of eating disorders (Southgate, Tchanturia, & Treasure, 2005)

This theoretical model concerns the socio-cognitive factors that may cause and perpetuate eating disorder symptoms (see **figure 1** for an overview). The model also integrates experimental findings from neuroscience. It suggests that risk factors for eating disorders include: (1) being female; (2) temperamental traits (such as behavioural inhibition, perfectionistic tendencies and cognitive rigidity); (3) traumatic stress; and (4) dieting as a response to challenging life events. Furthermore, the model hypothesises that insufficient nutritional intake due to dieting causes disruption in neurodevelopment (e.g., synaptic pruning) and collaborative brain function (Luna & Sweeney, 2004). This may make an individual vulnerable to an eating disorder as it interferes with inhibitory, reward and reflective processes. The model also suggests that adolescence is a time of heightened risk for eating disorders due to changes in the Social Information Processing Network (Nelson et al., 2005). This is because during puberty hormonal levels within the affective region of the cortex change (e.g., in the amygdala and the nucleus accumbens), which may lead to an increase in the emotional impact of a triggering stressor such as the experience of social rejection. Cognitive styles and personality traits may then predispose people towards developing specific eating disorder subtypes. For example, individuals with restrictive symptoms are typically overly inhibited, avoidant and affective in nature, whilst people with binge symptoms may be impulsive, uncontrolled and dysregulated.

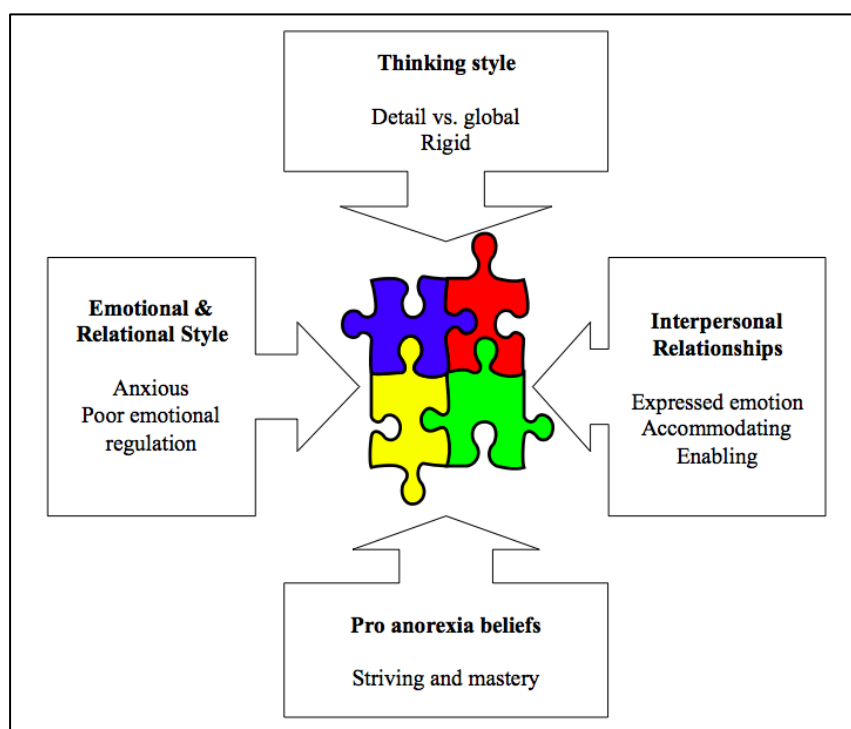


**Figure 1.** This schematic diagram outlines the socio-cognitive model of eating disorders (taken from Southgate, Tchanturia, & Treasure, 2005).



1.3.3. The cognitive-interpersonal maintenance model of AN (Schmidt, & Treasure, 2006; Treasure, & Schmidt, 2013)

The cognitive-interpersonal model describes how the **visible** aspects of AN (which are relevant for interpersonal processes) add to the **valued** elements (such as feelings of control), to maintain the illness. The model highlights several precipitating factors for AN, such as bullying and other highly stressful interpersonal events. These in combination with four key factors leads to the development and maintenance of the illness: (1) cognitive styles (e.g., highly detailed and rigid); (2) interpersonal relationships (e.g., high expressed emotion and accommodating/ enabling behaviours from others); (3) pro-anorexia beliefs (e.g., feelings of mastery); and (4) emotional/-relational styles (e.g., highly anxious, poor emotion regulation skills) (see **figure 2** for an overview). Once the illness takes hold, the model suggests that weight loss leads to secondary problems including a worsening in cognitive functions and increased feelings of isolation. This leads to a vicious cycle whereby the four core maintenance factors reinforce one another and the symptoms of the illness.



**Figure 2.** This schematic illustration of the cognitive-interpersonal maintain model of eating disorders, highlights four key factors that cause and perpetuate symptomatology.

1.3.4. A neurobiological hypothesis of AN; the role of the insula (Lask, & Frampton, 2011; Nunn, Frampton, Gordon, & Lask, 2008)

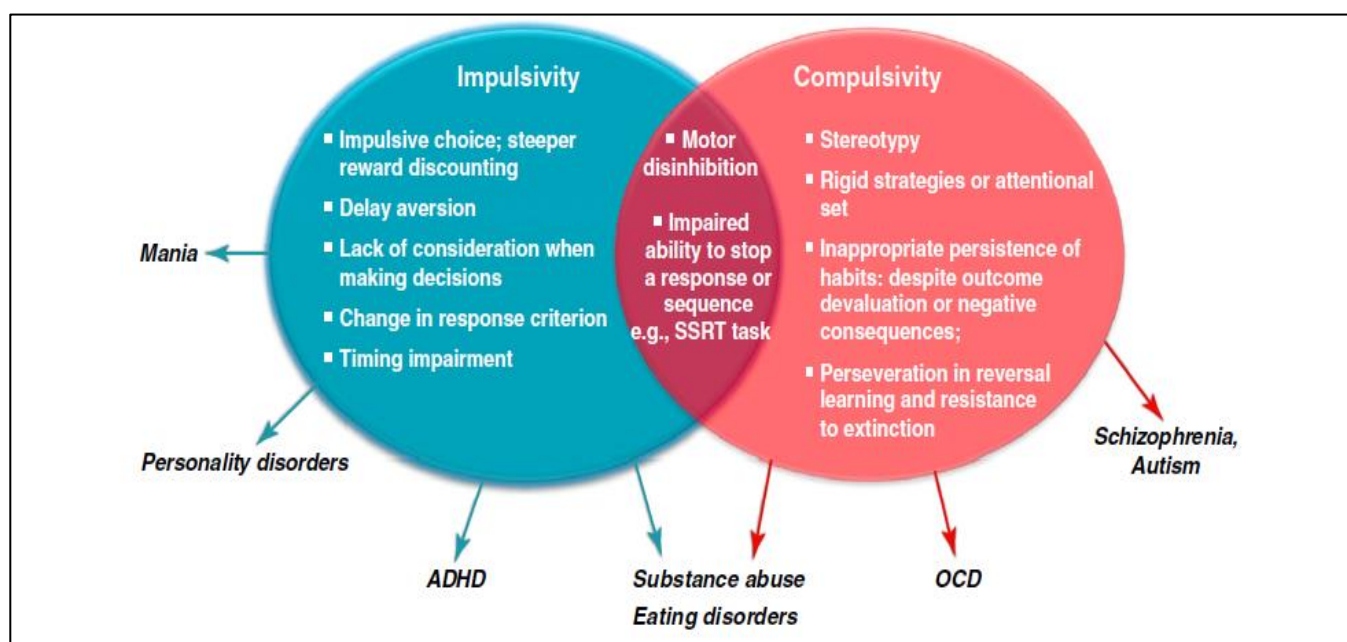
This model considers the role of both genetic and environmental factors in the development and maintenance of AN. It suggests that genetic factors cause noradrenergic dysregulation and, in turn, heightened levels of anxiety, lower levels of cerebral blood flow, and impaired neuroplasticity. Together, these factors lead to aberrant functioning of the insular cortex which underlies many symptoms of AN, because this area of the brain integrates information from the key neural substrates involved in AN symptoms. These neurobiological factors may combine with environmental stressors to cause AN. For instance, dieting may occur in response to triggers such as interpersonal difficulties. In the short term, dieting leads to a reduction in noradrenergic activity and reduced anxiety levels. As a result, dieting is initially experienced as rewarding. However, the noradrenergic system soon adapts and the feelings of anxiety return. This increase of anxiety also occurs during the process of refeeding, leading to the development of a maintenance cycle of the illness. If AN persists over time, symptoms of depression may develop (e.g., anhedonia, apathy) as the noradrenergic system ‘shuts down’ and anxiety levels reduce.

1.3.5. Interpersonal models of eating disorders (e.g., Arcelus, Haslam, Farrow, & Meyer, 2013; Atlas, 2004; Goss, & Gilbert, 2002; Rieger et al., 2010)

These models propose that negative social evaluation causes a decrease in an individual’s self-esteem and increases negative affect. The negative social evaluation may be specific to a person’s weight or shape or it may be a more general feeling of social rejection. In response to this negative feedback from others, eating disorder symptoms may develop as an attempt to increase feelings of self-worth and social acceptance, as well as an attempt to reduce negative affect. However, the eating disorder symptoms have the opposite effect, by compounding the individual’s intra-and interpersonal difficulties and their eating disorder symptoms. This interpersonal conceptualisation of eating disorders also suggests that eating disorders typically develop during adolescence because this is a time of life in which individuals are highly sensitive to the opinions and judgments of their peers.

1.3.6. Habit formation models of eating disorders (e.g., Pearson, Wonderlich, & Smith, 2015; Robbins, Gillan, Smith, de Wit, & Ersche, 2012; Walsh, 2013)

This cognitive neuroscience based formulation suggests that eating disorder symptoms may become highly engrained due to the process of excessive habit formation. This involves eating disorder symptoms transitioning from goal-orientated to stimulus-response driven behaviours. This formulation of eating disorders has been drawn from the substance abuse disorder literature whereby a similar process is hypothesised to occur (Everitt, & Robbins, 2005, 2016). As shown in **figure 3**, it is suggested that both impulsive and compulsive traits might underlie the symptomatology of these illnesses through dysregulated inhibitory control. The implication of these models is that interventions that help to interrupt stimulus-response driven behaviours, and improve cognitive control, may be beneficial.

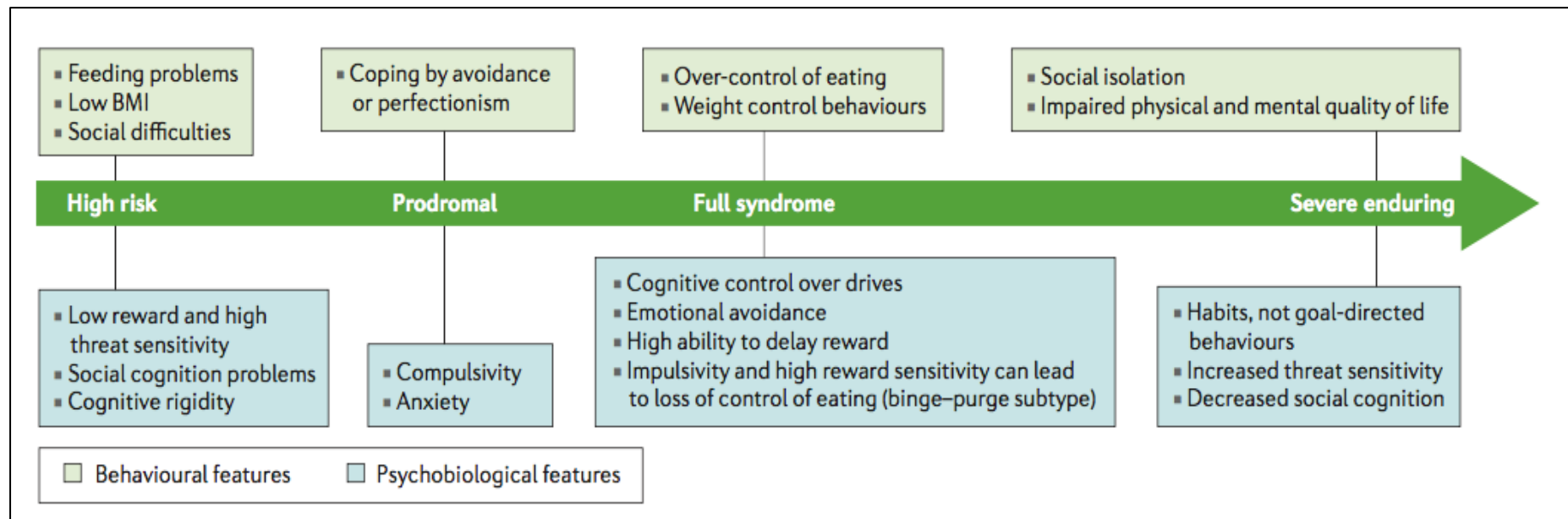


**Figure 3.** This highlights how impulsive and/ or compulsive traits might underlie a range of mental illnesses, including eating disorders (taken from Robbins et al., 2012).

### **1.3.7. A staging model of eating disorders (Treasure et al., 2015)**

As shown in **figure 4**, this model maps eating disorder psychopathology to the following stages: high risk, prodromal, full syndrome, and severe and enduring. During childhood and adolescence individuals may become predisposed towards the development of an eating disorder due to the presence of high-risk markers. Shyness, social problems, and obsessive-compulsive personality traits seem to predate the onset of AN (Anckarsäter et al., 2011; Gillberg et al., 1994; Wentz et al., 2009). The traits that precede BN include a tendency to overeat (Steiger & Bruce, 2007), and problems with attention and impulsivity that may manifest as attention-deficit/ hyperactivity disorder traits in childhood (Mikami et al., 2008; Seitz et al., 2013). A significant amount of evidence has also been found suggesting that childhood anxiety is also a high-risk marker for AN and BN (Godart et al. 2000). These vulnerability factors can lead to a prodromal phase characterised by sub-clinical symptoms. During this early stage of illness, symptoms can occasionally improve without engagement with clinical services, and increased rates of diagnostic cross-over occur. If prodromal symptoms do not remit, during early adulthood they may transition into the development of a ‘full-blown’ eating disorder.

The final stage outlined by the model is the severe and enduring stage of illness, which may be defined as a prolonged illness of over seven years duration. It is hypothesised that neuroprogressive changes brought about by poor nutrition and/or abnormal eating patterns and diminished psychosocial resources leads to the complex profile of morbidity characteristic of this later stage. For instance, evidence has been found that in the severe and enduring stage of AN brain size is reduced, particularly in the cerebellum and mesencephalon (Fonville et al., 2013). The atypical Blood-Oxygen-Level-Dependent (BOLD) response to illness relevant cues (for example salient body shape images) is more pronounced in adults than adolescents (Fladung et al., 2010; Fladung et al., 2013). A key point, highlighted by this model, is that social cognitive difficulties are pervasive across the course of eating disorders.



**Figure 4.** Taken from Treasure et al. (2015), this figure depicts the staging model of eating disorders and the psychobiological and behavioural features associated with the different stages of illness progression.

### 1.3.8. What do the main theoretical models of eating disorders have in common?

A recent systematic review by Penessi and Wade (2016) highlighted that there are several risk and maintenance factors that are common across the main theoretical models of eating disorders including, weight and shape concerns, interpersonal difficulties, low self-esteem, and problems in regulating emotions effectively. Therefore, theoretical models have been helpful in increasing understanding of the core factors involved in the development and maintenance of eating disorder psychopathology. However, the authors of the review also found that only 18.5% of the current theoretical models of eating disorders have been followed by the development of treatment approaches. Hence, more work is needed to translate the knowledge gained from theoretical models to clinical practice. This thesis aims to build upon this by examining in further detail the factors that may underlie eating disorder psychopathology and how new treatment approaches may be directly targeted at these processes. This will begin with a review of the existing treatment approaches for eating disorders and their evidence base.

## 1.4. The treatment of eating disorders

### 1.4.1. Primary, secondary and tertiary care; the different treatment settings for eating disorders

In the United Kingdom, general practitioners see people in primary care and are responsible for the initial identification and assessment of eating disorders and the co-ordination of further care. A comprehensive assessment of a person's mental and physical health, as well as their social needs, is recommended in order to determine an initial treatment plan (e.g., National Institute for Clinical Excellence, 2017; Surgenor, & Maguire, 2013). People may be referred onto a secondary care provider, such as a specialist eating disorder service, for further assessment and treatment. However, there can be a lack of awareness and knowledge of the symptoms of eating disorders in primary care, alongside long waiting-times for treatment (B-eat, 2015). Consequently, there is a need for more accessible and widely disseminable treatment approaches for people with eating disorders.

Specialist inpatient tertiary care is recommended when there are moderate to severe psychological (e.g., self-harm and suicide) or physical risks (e.g., cardiovascular problems) to the person or if outpatient care does not lead to any significant improvement in symptoms. Several goals for inpatient care have been suggested including: crisis intervention, a change of environment for the person, and the opportunity to provide a more intensive form of treatment (Vandereycken, 2003). In order to achieve these goals, inpatient care should take a holistic treatment approach by focusing on both psychosocial functioning and weight-restoration. Furthermore, it is recommended that inpatient services provide a structured, but flexible, treatment program that is not coercive, overly protective or excessively focused on target weights (Lask, & Frampton, 2009; Treasure, Crane, McKnight, Buchanan, & Wolfe, 2011).

#### 1.4.2. Psychological treatments for eating disorders

Regarding the early stages of AN, family-based therapies are recommended by treatment guidelines (e.g., Hay et al., 2014; National Institute for Clinical Excellence, 2017). A Cochrane systematic review has found that in the short-term family therapy is more effective than treatment as usual (Fisher, Hetrick, & Rashford, 2010). However, the review also highlighted several limitations associated with the literature to date, such as a paucity of randomised controlled trials, small samples sizes, and a limited amount of data on family functioning and mortality rates following treatment.

For adults with AN, three treatment options have been recommended: (1) the Maudsley Anorexia Nervosa Treatment for Adults (MANTRA); (2) individual eating-disorder-focused cognitive behavioural therapy (CBT-ED); and (3) specialist supportive clinical management (SSCM). If these therapies are not beneficial, it is then recommended that people be offered eating-disorder focal psychodynamic therapy (National Institute for Clinical Excellence, 2017).

Guidelines have recommended that CBT, possibly in a self-help format, should be the first line of therapy for people with BN or BED (Hay et al., 2014; National Institute for Clinical Excellence, 2017). CBT has been found to reduce eating disorder psychopathology, depression, anxiety, and other markers of poor quality of life (e.g., Turner, Marshall, Stopa,

& Waller, 2015; Waller et al., 2014). The failure of an early response within the first four weeks may signal the need to switch to other forms of treatment. Support for the use of specialist individual therapies, such as CBT-ED (Berg, 2014; Fairburn et al., 2003, 2015), and interpersonal psychotherapy has been found for patients with BN (Arcelus, Whight, Brewin, & McGrain, 2012; Champion, & Power, 2012). Behavioural weight loss interventions are also commonly used in the treatment of BED (Brownley et al., 2016).

There is a paucity of evidence from high quality trials to answer questions in the enduring stage of illness about which treatments are acceptable and how much benefit accrues. Once the illness has become severe and enduring there is less of a response to any form of treatment and there is uncertainty about clinical management (Hay et al., 2012; Wonderlich et al., 2012). The limited amount of evidence suggests that remission rates are modest and treatment acceptability is poor (Hay et al., 2014). Furthermore, treatment dropout can be high from outpatient treatment (Dejong et al., 2012), and 26-41% of people need additional in- or day-patient care, because of either a failure-to-improve or a deterioration of symptoms (Fairburn et al., 2013; Zipfel et al., 2014). Therefore, for people with very chronic illnesses, it may be beneficial to adopt a harm minimisation approach that focuses on improving quality of life and targeting any comorbidities (Westmoreland, & Mehler, 2016).

#### 1.4.3. Pharmacological treatments for eating disorders

Medication is recommended as an adjunct treatment for eating disorders (Hay et al., 2014; National Institute for Clinical Excellence, 2017). For AN, there is limited evidence for the use of pharmacological treatments. Olanzapine may be of benefit in low doses for increasing weight, decreasing anxiety, and obsessive thoughts (e.g., Aigner et al., 2011). However, a recent review of the literature suggested that at this stage clinical recommendations cannot be made regarding the use of Olanzapine for AN (Himmerich, & Treasure, submitted).

A daily 60 mg dose of the selective serotonin reuptake inhibitor Fluoxetine is effective in reducing binge-eating and purging episodes for people with BN (e.g., Fluoxetine Bulimia Nervosa Collaborative Study Group, 1992; Goldstein et al., 1995; Kanerva, Rissanen, &



Sarna, 1994; Romano et al., 2002). However, the abstinence rate is only 19%, and the long-term effects of the medication are less clear (Hay et al., 2014). Antidepressants are indicated for people with BED (e.g., citalopram, sertraline, desipramine and duloxetine). Furthermore, weight-loss medications, such as orlistat, are suggested for people with co-morbid obesity (Hay et al., 2014). Lisdexamfetamine dimesylate (Vyvanse) has recently been approved as a medication for the treatment of moderate to severe BED by the Food and Drug Administration in the United States. It is hypothesised that the drug might regulate dysfunctional dopamine systems (McElroy et al. 2016). A recent review of the literature found that over an 11 week trial a 50 or 70 mg/day dosage of lisdexamfetamine dimesylate is effective in reducing binge eating episodes for patients with a moderate to severe illness relative to a placebo (Citrome, 2015). However, this review highlighted that a long-term analysis of the treatment efficacy and safety profile of the drug is needed.

## **1.5. Chapter summary**

This chapter has covered the characteristics of eating disorders including their prevalence, incidence, co-morbidities, risk and maintenance models, and treatment. Significant progress has been made in the past few decades in understanding how to effectively treat eating disorders. Evidence has been found to support the use of family-based therapies for AN, and the efficacy of CBT and anti-depressant medication for people with BN and BED. However, despite these important advances, waiting lists and illness durations remain long, drop-out and relapse rates are high, and there are no evidence-based treatment approaches for people with severe and enduring illnesses. To improve this “current state of affairs”, increasingly researchers have called for the testing of new interventions that are translated from experimental medicine into clinical practice (e.g., Treasure, 2016; Voon, 2015). Therefore, the next chapter of this thesis will consider the use of novel cognitive training approaches for people with eating disorders.

# Cognitive training approaches for eating disorders

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*“We must make automatic and habitual, as early as possible, as many useful actions as we can, and guard against the growing into ways that are likely to be disadvantageous to us”.*

- William James (1890)

## **2.1. Chapter aims**

This chapter will focus on the rationale for this thesis. In order to improve treatment outcomes further, this chapter will hypothesise that treatments that are more precisely targeted at the key maintenance factors outlined in **chapter one** may be beneficial. Specifically, the use of novel cognitive training approaches for people with eating disorders will be considered. This chapter will end by outlining the aims and hypotheses for the rest of this thesis.

## **2.2. How can treatment outcomes be further improved for people with eating disorders?**

When developing new interventions there are a variety of steps to follow. The first is to build an accurate clinical profile of the various symptoms and model the underpinning psychopathology. The next stage is to consider possible techniques to foster change and to modify these dysfunctional systems. If we apply this process to eating disorders, then we are probably at the “drawing board” stage of model building especially for those in the severe and enduring stage of illness. This *precision psychiatry* approach aims to reduce the translational gap between clinical science and practice (Fernandes et al., 2017).

## **2.3. Mapping the mechanisms underlying psychopathology**

To identify the mechanisms that may underpin eating disorders for new treatments to target, it is important to consider the strengths and weaknesses of the classification systems for mental illness. This includes a consideration of alternate approaches for mapping the clinical profile of these illnesses.

### *2.3.1. DSM-5; a categorical versus dimensional approach to mental illness*

The DSM-5 and other diagnostic manuals, such as the International Classification of Diseases – 10<sup>th</sup> edition (ICD-10), use specific diagnostic criteria to classify an individual with having a mental illness. They are based upon a person’s description of their symptoms as opposed to the assessment of biomarkers. There are several strengths related to this

categorical approach for clinicians and researchers (Rief, & Martin, 2014). For instance, the use of established criteria worldwide means that diagnoses are made in a consistent manner. This aids clinicians in identifying disorders and in choosing a suitable treatment option. However, numerous challenges are also associated with this categorical approach to mental illness (Casey et al., 2013). For example, there are high rates of cross-over between diagnostic categories (e.g., people with AN may go on to develop BN and vice versa at a later stage of illness (Fairburn, & Harrison, 2003)). Hence, rather than being distinct clinical entities, as suggested by a categorical framework, there may be many mechanisms that are shared across diagnoses. This notion is in line with a dimensional conceptualisation of mental illness.

### *2.3.2. Transdiagnostic considerations: the Research Domain Criteria (RDoC) initiative*

The RDoC is an initiative from the National Institute for Mental Health (2016) that states a dimensional approach is needed to increase understanding of the mechanisms that might underpin a range of mental illnesses. It suggests that mental illnesses are brain-based and proposes five main domains of functioning for research to focus on across mental illnesses: (1) negative valence systems (e.g., fear, anxiety, and sustained threat); (2) positive valence systems (e.g., reward learning and habit formation); (3) cognitive systems (e.g., attention, cognitive control, and working memory); (4) systems for social processes (e.g., social communication, perception, and understanding of others); and (5) arousal/ regulatory systems (e.g., circadian rhythms and sleep/ wakefulness). These domains may be studied at numerous levels of analysis (e.g., genes, molecules, circuits, physiology, behaviour, and self-reports). Insel et al. (2010) states that this dimensional and more precise approach to mental illness might help facilitate the development of new treatments more rapidly than categorical approaches. This is because it will help to identify functions that are impaired in mental illnesses and hence, novel targets for treatment. Increasingly this approach is being applied to the field of eating disorders (e.g., Dunlop, Woodside, & Downar, 2016; Lutter, Croghan, & Cui, 2016; Reville, O'Connor, & Frampton, 2016; Wildes, & Marcus, 2015).

## 2.4. The rationale for more precise treatment approaches

It is possible that a more targeted approach to key cognitive maintenance factors may help to improve outcomes.

### 2.4.1. *The advantages of targeting automatic processes*

Dual-process models theorise that there are two key systems governing human behaviour. One system concerns **reflective** (conscious) and the other **automatic** (non-conscious) processes that underlie actions (e.g., Hofmann, Friese, & Strack, 2009; Strack, & Deutsch, 2004). Although there is debate as to whether these two systems are truly distinct from one another (e.g., Evans, & Stanovich, 2013), talking therapies, such as CBT, predominantly target reflective processes to change cognitions and behaviour. As a result, Hollands, Marteau and Fletcher (2016) have recently argued that in order to improve treatment outcomes for a range of health-related conditions further it is important for interventions to more precisely target automatic (non-conscious) processes. Their proposition is that because neuroscience has shown that the symptoms of many illnesses are automatic, stimulus-response driven actions, interventions that aim to disrupt these processes could be of significant benefit in addition to existing talking treatment approaches. These interventions may capitalise on the highly plastic nature of the brain to help facilitate behaviour change and to reduce symptomatology (see also, Marteau, Hollands, & Fletcher, 2012).

### 2.4.2. *“What fires together, wires together”* – Shatz (1992)

This phrase describes the concept of Hebbian learning: “When an axon of cell A is near enough to excite cell B and repeatedly and persistently take part in firing it, some growth process or metabolic change takes place in one or both cells such that A’s efficiency, as one of the cells firing B is increased (Hebb, 1949, p. 62). This process underlies neuroplasticity; the ability of the cortex to change in response to a host of experiences including motor actions, learning, associations, rewards, and mental rehearsal (Gentili et al., 2010; Morris, Rumsey, & Cuthbert, 2014; Pascual-Leone et al., 2005). The new understanding about brain plasticity has led to the development of a wide variety of interventions that guide this malleable potential of the brain through cognitive remediation training, drugs, transcranial

magnetic stimulation, and neurosurgical methods (e.g., Park, Godier, & Cowdrey, 2014; Schmidt, & Campbell, 2013). These novel treatment approaches could potentially be useful as adjunctive strategies to help improve the treatment outcomes of people with eating disorders.

#### 2.4.3. *“Which patient and disorder-related features can be used to provide more personalised treatment?”*

- van Furth, van der Meer and Cowan (2016)

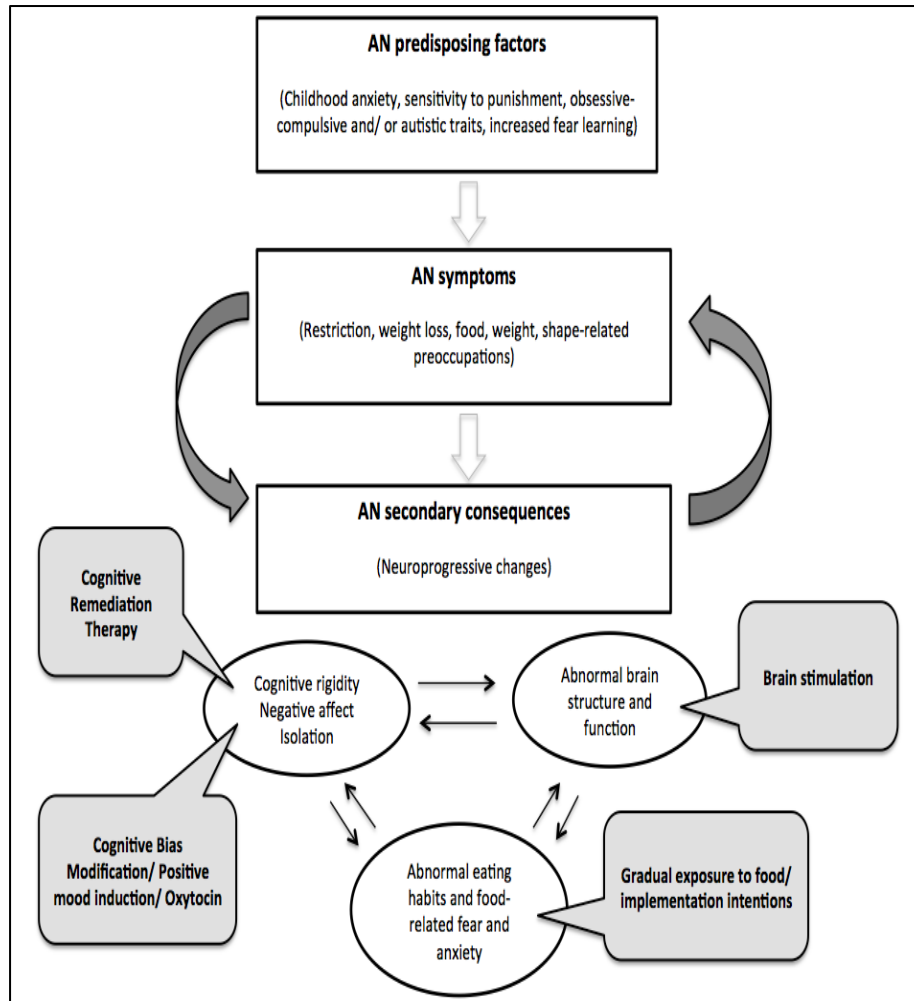
A collaboration between people with eating disorders, carers, and clinicians by the James Lind Alliance has raised this question as one of the top ten research priorities for the eating disorders field to address. The symptoms described previously in **chapter one** highlight several areas that can be targeted by more precise treatment approaches. For instance:

- Childhood anxiety, increased sensitivity to punishment and rejection, obsessive-compulsive and autism spectrum traits, and increased sensitivity to fear learning are some of the vulnerability factors which predispose to the onset of AN. Once the illness develops, core symptoms, such as restriction, weight loss and weight-, shape- and food-related preoccupations appear. With the illness progression, neuroprogressive secondary changes such as rigid eating habits, cognitive, emotional, and social difficulties, and abnormalities in brain structure and function develop and in turn reinforce the illness. It is suggested that new treatment approaches could be used to target the neuroprogressive changes which occur in AN.
- Abnormalities in appetite regulation, childhood anxiety, reward sensitivity, and inhibitory control are some of the vulnerability factors that predispose the onset of BN and BED. Once the illness develops, core symptoms, such as cycles of restriction and loss of control over eating and weight-, shape- and food-related preoccupations appear. With illness progression, neuroprogressive secondary changes, such as rigid eating habits and addictive-like changes; cognitive, emotional, and social difficulties

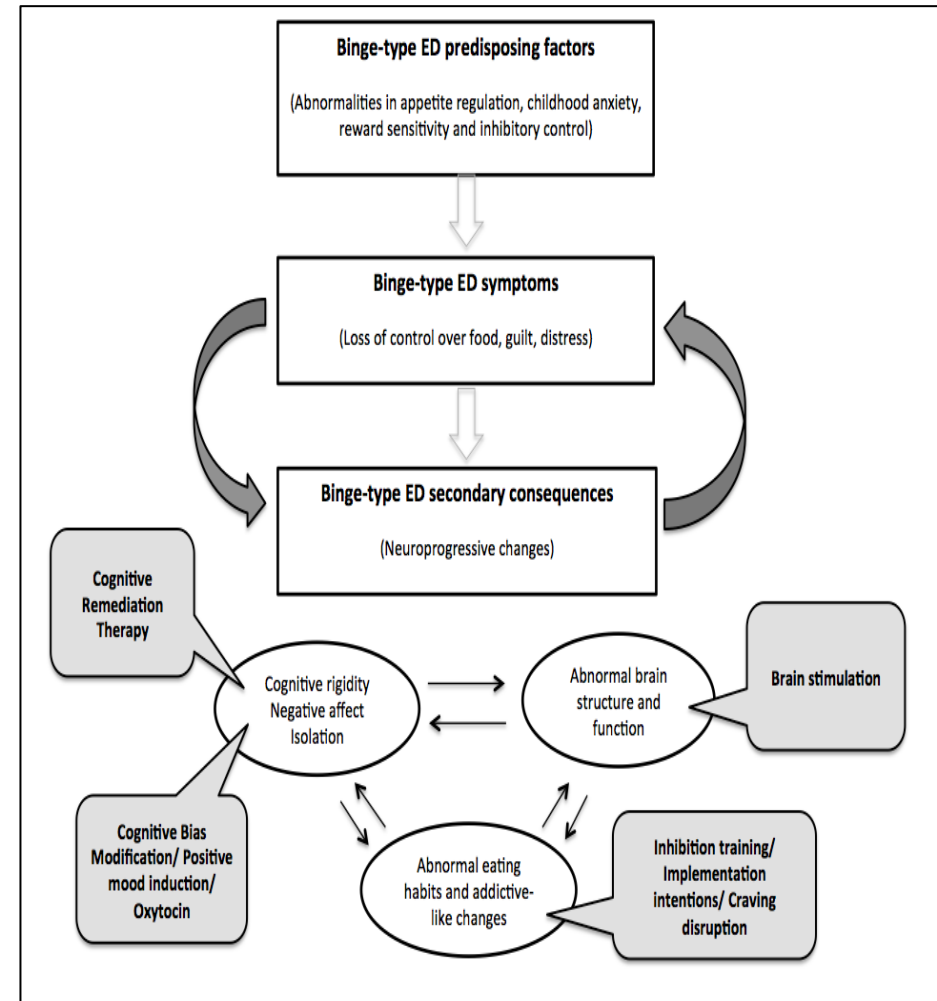
and abnormalities in brain structure and function develop and in turn reinforce the illness. It is suggested that new treatment approaches could be used to help target the neuroprogressive changes that occur in BN and BED. Please also **see chapter six** for a more detailed review of possible targets for the treatment of binge-type eating disorders based upon the latest findings from animal models of eating behaviour.

New treatment approaches, such as cognitive training and neuromodulation techniques, may be targeted at these illness mechanisms and tailored to the individual needs of someone with an eating disorder (please **see figure 1** for an overview of potential targets and new treatment approaches). This is in line with the premise that treatments for eating disorders and their co-morbidities should no longer, “remain brainless” (p.425, Schmidt, & Campbell, 2013). However, the realisation of this proposition is still at an early stage, pending further research into the mechanisms underlying eating disorders and the successful piloting of novel interventions (e.g., Dalton, Campbell, & Schmidt, 2017; Schmidt, & Campbell, 2013).

A)



B)



**Figure 1.** Taken from Treasure et al., 2015; A) shows the possible use of targeted treatment approaches for people with AN, and B) similarly shows this for people with binge-type eating disorders such as BN and BED.



## 2.5. The focus of this thesis

The literature covered in **chapter one** of this thesis highlighted that a range of social and cognitive factors may both predispose and perpetuate eating disorder symptoms across diagnoses (e.g., Fairburn, Cooper, & Shafran, 2003; Southgate, Tchanturia, & Treasure, 2005; Treasure & Schmidt, 2013). Despite this knowledge, there remains a lack of understanding of the specific psychological mechanisms that may underpin these socio-cognitive factors (Treasure et al., 2015). Potential candidate processes that have recently been hypothesised to subserve eating disorder symptoms have included rejection sensitivity (as outlined by the model of Rieger et al., 2010) and inefficient cognitive/ inhibitory control (as suggested by Pearson, Wonderlich, & Smith, 2015; Robbins, Gillan, Smith, de Wit, & Ersche, 2012; Walsh, 2013). These aforementioned processes are also in line with the RDoC recommendation to consider the role of systems for social processes and cognitive systems in mental illnesses (National Institute for Mental Health, 2016). Therefore, the following section of this chapter will provide an overview of these processes in more detail and novel training approaches that may target them. This will include a description of the approaches themselves, and the evidence in eating disorders to date.

## **2.6. Social processes in AN**

### 2.6.1. Rejection sensitivity and a negative interpretation bias

*“My brain wasn't working due to severe food restriction and bingeing-purging behaviours, so I felt dumb in addition to lonely. And beyond dumb and lonely, I felt like a burden to my friends and family. I truly believed people would be better off without me and like I didn't fit in the world I was living in”.*

- Solomon and Trainor (2016), p.88.

Social belonging is a basic human need and is associated with both physical and psychological health (Baumeister, & Leary, 1995; Hale, Hannum, & Espelage, 2005). Conversely, social rejection has a profoundly negative impact on well-being (DeWall, & Bushman, 2011; Wright, Gronfein, & Owens, 2000). For instance, research has shown that

social rejection is associated with increased activation in the areas of the cortex that are also involved in the response to physical pain; the anterior insula and the dorsal anterior cingulate cortex (Eisenberger, Lieberman, & Williams, 2003). Furthermore, several mental health problems are thought to be associated with difficulties relating to the perception/ experience of social rejection (Fung, Xu, Glazier, Parsons, & Alden, 2016). As previously highlighted in **chapter one** this includes eating disorders, with Rieger et al. (2010) hypothesising that, “social interactions characterised by rejection both trigger and are triggered by eating disorder behaviours” (p. 405).

A negative interpretation bias for social stimuli is a cognitive bias that might be associated with rejection sensitivity and eating disorder psychopathology. For instance, everyday social interactions are full of ambiguity, in that they can be open to many different explanations and resolutions. If a person messages their partner to arrange to meet up and they don't reply soon after, a benign interpretation of the situation could be that the person is currently busy at work or has not checked their phone recently. Whereas a negative interpretation could be that the person is purposefully ignoring their message. In response to such ambiguity, the tendency for an individual to consistently make interpretations in either a negative or positive manner has been described as an *interpretation bias* (Hirsch et al., 2016).

Given that a negative interpretation bias might increase the likelihood of perceiving ambiguous social scenarios in a more threatening manner, it may be a factor that contributes to rejection sensitivity in people with eating disorders. Hirsch et al. (2016) outline two approaches for investigating the role of interpretation bias in mental illnesses. One approach is to compare individuals with the illness to a group of healthy controls to discover if an interpretation bias is apparent. The other involves experimentally manipulating the bias within individuals with the illness to examine its effect on other symptoms.

#### 2.6.2. Methods to assess for an interpretation bias in people with eating disorders versus healthy controls

So far, research has not investigated whether people with eating disorders have a negative interpretation bias in comparison to a healthy comparison group. Numerous paradigms have been developed to assess for an interpretation bias (please see Hirsch et al.,

2016 for a detailed review). These paradigms may be split into two broad categories: ‘offline’ and ‘online’ approaches. Offline assessment procedures include procedures such as sentence completion tasks, which involve participants generate completions for ambiguous scenarios. The advantage of this approach is that participants produce the responses themselves, rather than them being forced to select a completion from pre-defined options. Online assessment methods have also been created; these measure response latencies to infer an interpretation bias. For example, reading time tasks (e.g., the time that participants take to read negative or benign completions to ambiguous scenarios are recorded). These assessment approaches may be used by research to examine whether individuals with eating disorders have an interpretation bias.

### 2.6.3. Cognitive Bias Modification (CBM)

Novel approaches have been created to manipulate cognitive biases. Indeed, CBM procedures have been developed with the purpose of modifying negative cognitive biases in interpretation and attention. There are two main variants of CBM procedures, both of which are computerised (e.g., Grey, & Mathews, 2000; Mathews, & Mackintosh, 2000; MacLeod, & Matthews, 2012). One approach is targeted at changing negative biases in attention through the use of a modified visual version of the dot-probe task (MacLeod et al., 1986). The other CBM approach helps to remediate negative biases in interpretation. This approach typically involves people listening via headphones to ambiguous scenarios that have the risk for a negative interpretation (e.g., *you haven’t spoken to a close friend in a while so you message them to see how they have been. It’s been several hours since you messaged them but they haven’t replied, you think that they are...*), but they are given a benign resolution (e.g., **busy at the moment**).

### 2.6.4. CBM findings in other mental illnesses

CBM approaches have been used in a range of clinical populations including emotional disorders (e.g., Blackwell, & Holmes, 2010; Hayes et al. 2010; Williams, Blackwell, Mackenzie, Holmes, & Andrews, 2013), obsessive-compulsive disorder (e.g., Salemink et al. 2015), and substance use disorders (e.g., Wiers, Gladwin, Hofmann, Salemink, & Ridderinkhof, 2013). Quantitative data indicate that CBM can remediate negative

attention and interpretation biases towards emotionally relevant stimuli (e.g. facial expressions; emotionally valenced words) or anxiety- and depression-specific stimuli with a moderate sized effect in clinical and sub-clinical populations (Hedges'  $g = 0.49$ ; Hallion & Ruscio, 2011). This effect was found to be greater for remediating negative biases in interpretation (Hedges'  $g = 0.81$ ) than in attention (Hedges'  $g = 0.29$ ). Also, a recent meta-analysis found that benign interpretation training was associated with a significant increase in positive interpretations and decrease in negative mood in healthy controls, subclinical, and clinical populations (Menne-Lothmann et al., 2014).

#### 2.6.5. CBM for eating disorders

In a proof of concept study, Yiend et al. (2014) tested a single session of CBM training in a subclinical sample. The training specifically targeted negative self-beliefs and was associated with a significant reduction in eating disorder cognitions (i.e., a decrease in negative thoughts during weighing and when viewing a mirror). Furthermore, a recent study by Cardi et al. (2015) tested the use of five sessions of combined CBM attention and interpretation bias training for social stimuli that depict the risk of social rejection in a sample of 28 inpatients with AN. Findings indicated that at the end of intervention, participants showed a medium sized increase in attention to socially accepting stimuli (smiling faces) and fewer negative interpretations of social stimuli that involve the potential of rejection. Also, there was an increase in self-compassion and decrease in self-reported symptoms of anxiety. These positive preliminary findings suggest that CBM might have potential in targeting negative information processing styles in eating disorders.

Despite the positive findings so far relating to the use of CBM in eating disorders, there are many unanswered questions. For instance, it remains to be tested whether a CBM approach modifies core eating disorder symptoms, such as eating behaviour, and how effective CBM training is for women in the community with AN. This may be considered an important population to trial CBM training for given the heightened levels of isolation reported by women in the community with AN (e.g. Knight, 2009; Solomon and Trainor, 2016). Furthermore, another population that CBM training has not been tested for is adolescents with AN. As covered in **chapter one**, interpersonal theories of eating disorders have proposed that eating disorders predominately begin during adolescence, as this is a time of life in which individuals become highly sensitive to social rejection from peers (Rieger et al.,

2010). Therefore, given the saliency of rejection sensitivity in adolescence (e.g., Sebastian et al., 2011), it also seems warranted for research to also examine the effectiveness of CBM training in this group.

## **2.7. Cognitive control in binge-type eating disorders**

### 2.7.1. Inhibitory control in eating disorders

In **chapter one**, inefficient inhibitory control was highlighted as a cognitive process that may underlie the impulsive/ compulsive nature of eating disorders. Specifically, it has been suggested that there are excessive levels of self-control over eating in people with AN, through to a loss of control and dysregulation in people with BN and BED (Berner & Marsh, 2014; Schulte, Grilo, & Gearhardt, 2016; Wierenga et al., 2014). A systematic review and meta-analysis of the literature by Wu, Hartmann, Skunde, Herzog and Friederich (2013) found small effects for impaired general inhibitory control in BN (Hedges'  $g = -.26$ ) and BED (Hedges'  $g = -.16$ ). Of note, a significant large effect size was found for impaired inhibitory control of food and eating stimuli in people with BN (Hedges'  $g = -.67$ ). Also, Svaldi, Naumann, Trentowska & Schmitz (2014) reported that in BED the degree of impairment in food-specific inhibitory control positively correlates with the severity of eating disorder psychopathology. Hence, as inefficient food-specific inhibitory control could be an important illness mechanism in binge-type eating disorders, experimental psychopathology studies seem warranted which directly target and modify this process. This may pave the way for the development of new treatment approaches in future research.

### 2.7.2. Food-specific inhibition training

Food go/no go training has been developed as a novel computerised approach to help train individuals to inhibit their automatic impulses towards high-calorie foods. This technique involves the presentation of food stimuli onscreen that are paired with either a go/no-go cue. The go cue is a thin rectangle around the food item and the no-go cue is a bold rectangle around the food item. Participants are instructed that they should respond by pressing a computer key when a go cue is presented and that they must withhold their response when a no-go cue is presented. No-go cues are consistently matched with the pictures of high-calorie food and go cues linked with alternate, and more adaptive, food

choices (e.g., low-calorie food items). Thereby, this task uses a choice reaction time method to train participants to increase their inhibitory control over high-calorie binge foods.

Research has suggested that food-go/ no-go training is a promising method to help reduce the consumption of high-calorie foods in restrained eaters (e.g., Adams, Lawrence, Verbruggen, & Chambers, 2017; Houben & Jansen, 2011; Lawrence, Verbruggen, Morrison, Adams, & Chambers, 2015b; Veling Aarts, & Papies, 2011). Furthermore, go/ no-go training has been reported to lower high-calorie food consumption (two weeks of training; Blackburne, Rodriquez, & Johnstone, 2016), and to reduce how much participants ‘like’ high-calorie foods (one week of training; Lawrence et al., 2015a), in overweight and obese people.

There are several mechanisms that are hypothesised to underlie the effect of food-specific inhibition training (Stice, Lawrence, Kemps, & Veling, 2016; Veling, Lawrence, Chen, Van Koningsbruggen, & Holland, 2017). These include: (1) the training increases automatic and/or reflective inhibitory control processes; (2) it produces food devaluation (the liking or value of high-calorie food decreases); (3) visual attention towards the high-calorie foods is reduced (as people begin to value high-calorie foods less their attention towards them may decrease); and (4) motor excitability towards the high-calorie foods may be reduced (as a result of reducing approach tendencies). **Chapter seven** of this thesis will systematically review the food-specific inhibition training literature in further detail, to establish the effectiveness of this training approach and its potential for people with eating and weight disorders.

### 2.7.3. Inhibitory control training; findings in other mental illnesses

Computerised go/ no-go training approaches have been adapted to increase inhibitory control towards alcohol cues in regular/ heavy drinkers (Bowley et al., 2013; Houben, Nederkoorn, Wiers, & Jansen, 2011; Houben, Havermans, Nederkoorn, & Jansen, 2012; Jones & Field, 2013). Meta-analyses of studies testing inhibitory control training for alcohol consumption have found a medium sized reduction in alcohol consumption (Cohen’s  $d = .43$ ; Allom, Mullan, & Hagger, 2016; Jones et al., 2016). Based upon these promising findings, trials are currently underway to test the effectiveness of the approach for adults with

substance use disorders (e.g., Jones, McGrath, Houben, Nederkoorn, Robinson, & Field, 2014).

#### 2.7.4. Food-specific inhibitory control training for eating disorders

Targeting impulsive actions such as loss of control over eating through strengthening inhibitory processes through training is potentially a valuable technique for people with eating disorders. This is because people with BN and BED typically over consume high-calorie foods (e.g., deserts and snacks) during binge-eating episodes (Rosen, Leitenberg, Fisher, & Khazam, 1986). Furthermore, experimental studies have shown that they have increased responsivity and cravings for high-calorie food items relative to healthy CW (Simon et al. 2016). These findings are similar to substance use disorder, whereby drug-cues can elicit intense cravings and activation of the reward circuitry within the brain (Blum, Liu, Shriner, & Gold, 2011; Goodman, 2008). Therefore, as for substance use disorders, it may be beneficial to pilot inhibitory control trainings for eating disorders. However, to date there has been no research using food go/ no-go training for people with eating disorders.

### **2.8. Chapter summary**

In order to improve treatment outcomes further more precise, targeted approaches to key cognitive maintenance factors may be useful. This is because: (1) they may more directly target automatic brain processes than talking therapies; (2) they could utilise the potential of neuroplasticity to enhance cognitive functioning; (3) they potentially disrupt the learned stimulus-response behaviours underlying symptomatology; and (4) they have the potential to be used as adjunctive treatment enhancers alongside approaches such as CBT. CBM and food-specific inhibition training are cognitive training approaches that may be effective in targeting eating disorder maintenance factors. The aim of thesis will be to examine in further detail the mechanisms that may be targeted by these interventions (i.e., social interpretation biases and inhibitory control in eating disorders). It will also pilot these training approaches in people with eating disorders to examine their effectiveness in modifying core symptomatology. These experimental studies were all conducted in parallel to one another due to time constraints owing to the processes of designing the studies, gaining ethical approval, recruitment, analysis and dissemination of the findings. See **table 1** for an overview of the specific aims and hypotheses of the experimental studies included within this thesis.

## Aims and hypotheses for the thesis

Chapters	Aims	Hypotheses
<b>Chapter three</b> (Study one)	To examine whether women with AN have a systematic negative interpretation bias for ambiguous social stimuli.	Women with AN will produce more negative, and less benign, interpretations for ambiguous social stimuli relative to healthy eaters.  This negative interpretation bias will correlate with core eating disorder symptoms, depression, anxiety, and rejection sensitivity.
<b>Chapter four</b> (Study two)	To investigate the impact of an experimental and control condition of CBM-I on interpretational styles and eating behaviour in adults with AN.	Women with AN will make significantly fewer negative, and more benign, interpretations and consume more on a test meal after an experimental versus control session of CBM-I.
<b>Chapter five</b> (Study three)	To examine whether there is a negative interpretation bias for social stimuli in an adolescent inpatient group with AN.  To test the effectiveness of CBM-I in reducing sensitivity to social rejection.	An experimental session of CBM-I training will help to reduce a negative interpretation bias in adolescents with AN in comparison to a control session.  Further, CBM-I will decrease sensitivity to social rejection in response to a Cyberball task, in comparison to control CBM-I.
<b>Chapter eight</b> (Study four)	To examine whether one session of food-specific go/ no-go training versus general inhibitory control training modifies eating behaviour in people with BN and BED.	Women with BN and BED would reduce their intake of high-calorie foods more than in the general training condition and increase low-calorie food consumption.  Also, it was predicted that eating binge-eating/ purging would decrease in the 24-hours post-training.

**Table 1.** This summarises the key aims and hypotheses of the experimental studies included within this thesis. Abbreviations: AN = Anorexia nervosa, CBM-I = Cognitive Bias Modification for Interpretation biases; BN = Bulimia Nervosa; and BED = Binge Eating Disorder.



### Study one

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**\* Joint first author**

## BRIEF REPORT

# Biased Interpretation of Ambiguous Social Scenarios in Anorexia Nervosa

Valentina Cardi<sup>\*,†</sup>, Robert Turton<sup>†</sup>, Sylvia Schifano, Jenni Leppanen, Colette R. Hirsch<sup>†</sup> & Janet Treasure<sup>†</sup>

Department of Psychological Medicine, Institute of Psychiatry, Psychology and Neuroscience, King's College London, London, UK

## Abstract

Patients with anorexia nervosa experience increased sensitivity to the risk of social rejection. The aims of this study were to assess the interpretation of ambiguous social scenarios depicting the risk of rejection and to examine the relationship between interpretation biases and clinical symptoms. Thirty-five women with anorexia nervosa and 30 healthy eaters completed clinical questionnaires, alongside a sentence completion task. This task required participants to generate completions to ambiguous social scenarios and to endorse their best completion. Responses were rated as being negative, neutral or positive. Patients endorsed more negative interpretations and fewer neutral and positive interpretations compared with healthy eaters. The frequency of endorsed negative interpretations correlated with depression, anxiety and fear of weight gain and body disturbance. A negative interpretation bias towards social stimuli is present in women with anorexia nervosa and correlates with clinical symptoms. Interventions aimed at reducing this bias could improve illness prognosis. Copyright © 2016 John Wiley & Sons, Ltd and Eating Disorders Association.

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## Keywords

anorexia nervosa; rejection sensitivity; interpretation bias; transdiagnostic

## \*Correspondence

Valentina Cardi, Section of Eating Disorders, Institute of Psychiatry, Psychology and Neuroscience, King's College London, 103 Denmark Hill, London, SE5 8AZ, UK.  
Email: valentina.cardi@kcl.ac.uk

<sup>†</sup>Joint first author

<sup>†</sup>Joint last author

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## Introduction and aims

There has been growing interest in mapping the psychopathology of mental disorders through a transdiagnostic framework (Krueger & Eaton, 2015). This is exemplified by the Research Domain Criteria initiative (National Institute of Mental Health, 2016) that promotes a dimensional approach to psychopathology and the use of multiple levels of analysis in studying human behaviour (e.g. genes, circuits, behaviours). A dimension of functioning that is affected in most psychiatric disorders is the one related to interpersonal relationships (i.e. systems for social processes). In particular, a systematic negative interpretation of social encounters is found in a range of emotional disorders and is causally implicated in the maintenance of key symptoms, such as anxiety, worry and rumination (for a recent review, see Hirsch, Meeten, Krahé, & Reeder, 2016). Despite the large phenotypic overlap between emotional disorders and eating disorders, the presence of a negative interpretation bias of ambiguous social stimuli has not been established in eating disorders. This seems a missed opportunity for advancing transdiagnostic considerations and treatment options for these challenging conditions.

Several etiological hypotheses suggest a role for social adversity and hypersensitivity to the threat of social exclusion in the development and maintenance of eating disorders. The proposal is that disordered eating behaviours and attempts to control weight and

shape serve as coping mechanisms to try to fit in the social world and deal with the negative affect elicited by expected and/or actual negative feedback from others (e.g. Arcelus, Haslam, Farrow, & Meyer, 2013; Goss & Gilbert, 2002; Rieger et al., 2010; Treasure & Schmidt, 2013). Over time, eating disorder symptoms become habitual and isolate the individual further, by fuelling deficits in social cognition and interpersonal skills (for a review, Caglar-Nazali et al., 2014; Treasure, Stein, & Maguire, 2015).

Preliminary evidence suggests that people with eating disorders are more sensitive to negative social interactions (i.e. participants with bulimic symptoms; Steiger, Gauvin, Jabalpurwala, Séquin, & Stotland, 1999) and rejection (i.e. mixed samples of participants with anorexia nervosa or bulimia nervosa; Cardi, Di Matteo, Corfield, & Treasure, 2013; Maier et al., 2014) and experience high levels of unfavourable social comparison (i.e. mixed samples of participants with anorexia nervosa or bulimia nervosa; Cardi, Di Matteo, Gilbert, & Treasure, 2014; Troop & Baker, 2008). Patients also perceive less warmth from others (i.e. a sample of participants with anorexia nervosa; Ambwani et al., 2016) and show attentional biases towards faces expressing rejection and social rank-related information (i.e. dominance or submissiveness; mixed samples of participants with anorexia nervosa or bulimia nervosa; Cardi et al., 2013, 2014, 2015), compared with people who have never suffered from an eating disorder. In line with these behavioural findings, neuroimaging studies indicate

that patients with anorexia nervosa display increased activation of the attention network during rejection feedback (Via et al., 2015) and reduced cortical activation when perceiving kindness during a trust game (McAdams, Lohrenz, & Montague, 2015).

To date, no research has been undertaken to establish whether people with eating disorders display a systematic negative interpretation bias of ambiguous social cues. With the overall aims of broadening the evidence on the transdiagnostic nature of this process and to inform the development of new targeted treatments, this study investigates interpretation biases towards social scenarios depicting the risk of rejection in a sample of participants with anorexia nervosa. A secondary aim is to explore whether this bias relates to rejection sensitivity, self-reported anxiety and depression and psychopathological symptoms more specific to anorexia nervosa, such as fear of weight gain and body image disturbance.

## Method

### Participants

Thirty-five female participants with anorexia nervosa (27 inpatients from the Bethlem Royal Hospital and 8 volunteers from the community) and a group of 30 healthy eaters from the community were recruited for the study through advertisements. Inclusion criteria for the clinical group included females aged between 18 and 60 years old with no severe comorbidity (i.e. psychosis). With regards to the healthy group, the criteria were females (18–60 years old) and no lifetime diagnosis of eating disorders, anxiety or mood disorders. To check eligibility, participants were screened by using a tailored version of the Structured Clinical Interview for DSM-IV Axis I Disorders (First, Spitzer, Gibbon, & Williams, 2002), which included the overview, eating disorder sections and questions on the experience of anxiety or mood disorders.

### Materials

Short Evaluation of Eating Disorders (Bauer, Winn, Schmidt, & Kordy, 2005)

This measure requires participants to report their BMI and to rate their level of psychopathological symptoms, including fear of weight gain and body image disturbance. The Short Evaluation of Eating Disorders has been found to have good concurrent validity between clinician and patients' ratings (Bauer et al., 2005). The Cronbach's alpha in this study was 0.81.

Depression Anxiety Stress Scales (Lovibond & Lovibond, 1995)

The Depression Anxiety Stress Scale is a 21-item questionnaire that measures participants' depression, anxiety and stress levels over the past week. The questionnaire has been found to be both a reliable and valid measure (Antony, Bieling, Cox, Enns, & Swinson, 1998). The Cronbach's alpha in this study was 0.97.

Adult Rejection Sensitivity Questionnaire (Downey & Feldman, 1996)

This measure includes nine hypothetical social scenarios that involve the potential for rejection. Participants must rate their

level of concern or anxiety related to the outcome of the scenario and also how likely they think that they would be either accepted or rejected. Previous research has found that the Adult Rejection Sensitivity Questionnaire has good internal consistency and test–retest reliability (Berenson, Downey, Rafaeli, Coifman, & Leventhal Paquin, 2011). The Cronbach's alpha for the clinical group in this study was 0.73.

Sentence completion task (modified from Huppert, Pasupuleti, Foa, & Mathews, 2007; Hayes, Hirsch, Krebs, & Mathews, 2010)

This computer-based task requires participants to listen over headphones to 12-stem sentences (2 practice trials to familiarise participants with the task and 10 test trials) that describe ambiguous social scenarios (e.g. 'As you walk into a group of people, they stop talking because they were talking about...'). Participants write down as many short word completions to the scenarios as they can. For each scenario, they are asked to indicate with an asterisk the completion that they think best completes the scenario. The completions are then rated as 'positive', 'negative' or 'neutral' by two independent raters. The task was adapted from previous research (Hayes et al., 2010; Huppert et al., 2007). The sentences used have been selected from an existing pool of stimuli developed to measure interpretation biases in socially anxious individuals (Huppert et al., 2007). The research team (four individuals) independently selected a subgroup of sentences ( $n = 20$ ) that were most likely to be potentially interpreted in a positive (i.e. social acceptance) or negative (social rejection/criticism) way.

### Procedure

The study was carried out in accordance with the latest version of the Declaration of Helsinki, and ethical approval was received from a National Health Service Research Ethics Committee. Informed written consent was given by all participants. Testing took place either at the Bethlem Royal Hospital or at King's College London. Participants completed the questionnaires followed by the sentence completion task, which was done on a laptop (by using E-PRIME, version 2). Some of the data for the inpatient clinical group were taken from the initial assessment of a study that was then followed by a wider cognitive bias modification training (Cardi et al., 2015).

### Data analysis

Clinical characteristics were compared between participants with anorexia nervosa and healthy eaters by using *t*-tests (SPSS version 22). Responses on the sentence completion task were rated as being negative, neutral or positive by two of the researchers independently, who were not informed of group allocation (J.L. and S.S.) ( $k = 0.97$ ). Three variables for the sentence completion task were considered: 'best completion', 'first completion' and 'total completions'. The sentence completion task data was not normally distributed; therefore, the Mann–Whitney *U* test was used. Spearman's *rho* was calculated to correlate the frequency of endorsed negative interpretations with sensitivity to rejection, symptoms of anxiety and depression and symptoms more specific to the anorexia nervosa phenotype, such as fear of weight gain and body disturbance (i.e. feelings of fatness). To account for possible false discoveries due to multiple comparisons, the Benjamini and



Hochberg (1995) procedure was used. Results were interpreted as significant when  $p \leq .04$ . Effect sizes were expressed by using the correlation effect ' $r$ ' and interpreted as small ( $\geq .10$ ), medium ( $\geq .30$ ) and large ( $\geq .50$ ) (Cohen, 1988).

## Results

### Demographic and clinical characteristics

An overview of participants' demographic and clinical characteristics is shown in Table 1. Twenty-three participants with anorexia nervosa (65.7%) were taking psychiatric medication at the time of testing, and 14 (40%) reported comorbid anxiety or depression when assessed with the Structured Clinical Interview for DSM-IV Axis I Disorders. In line with this, participants with anorexia nervosa reported greater levels of depression, anxiety and stress on the Depression Anxiety Stress Scale questionnaire. Patients scored higher than healthy eaters also in relation to sensitivity to rejection.

### Sentence completion task

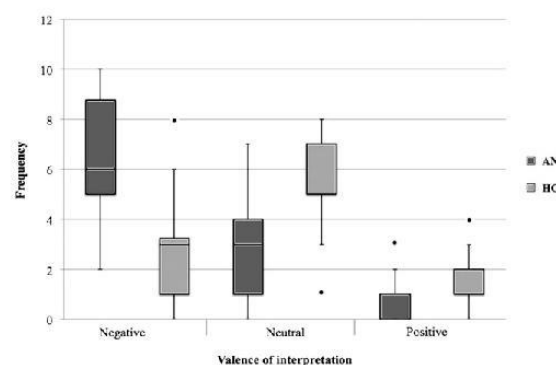
#### Endorsed 'best' completions

The number of endorsed negative interpretations made on the sentence completion task was greater for participants with anorexia nervosa [ $Mdn = 6$ , interquartile range (IQR) = 5–9] than healthy eaters [ $Mdn = 3$ , IQR = 1–3.2;  $U = 131.5$ ,  $p < .0001$ ,  $r = .65$ ], whereas the number of endorsed neutral or positive interpretations was lower in the clinical group (neutral interpretations:  $Mdn = 3$ , IQR = 1–4; positive interpretations:  $Mdn = <0.0001$ , IQR =  $<0.0001$ –1) compared with healthy eaters (neutral interpretations:  $Mdn = 5$ , IQR = 5–7;  $U = 150.5$ ,  $p < .0001$ ,  $r = .62$ ; positive interpretations:  $Mdn = 2$ , IQR = 1–2;  $U = 175.5$ ,  $p < .0001$ ,  $r = .6$ ). Figure 1 presents an overview of these findings.

A similar pattern of results with large effect sizes was found for the frequency of first and total interpretations made on the sentence completion task (for further details, see the Supplementary Materials).

### Correlations

The frequency of endorsed negative interpretations (best completions) correlated significantly with self-reported sensitivity to



**Figure 1.** The frequency of participants' endorsed 'best' completions on the sentence completion task, categorised as being negative, neutral or positive interpretations

rejection ( $r_s = .3$ ,  $p = .05$ ), although this correlation did not survive correction for multiple comparisons. As expected, the frequency of endorsed negative interpretations correlated positively not only with symptoms of depression ( $r_s = .4$ ,  $p = .008$ ) and anxiety ( $r_s = .5$ ,  $p = .003$ ) but also with psychopathological symptoms specific to anorexia nervosa, such as fear of weight gain ( $r_s = .7$ ,  $p < .0001$ ) and feelings of fatness ( $r_s = .4$ ,  $p = .01$ ).

## Discussion

The aims of this study were to compare how people with anorexia nervosa interpret socially ambiguous scenarios depicting the risk for rejection in comparison with a group of healthy eaters and to broaden the evidence on the transdiagnostic nature of this biased process. According to the predictions, patients endorsed more negative interpretations and fewer neutral and positive interpretations than healthy eaters (large effect sizes) and also reported higher levels of rejection sensitivity (large effect). This same pattern of results (i.e. more negative interpretations; fewer positive and neutral) was found for the first completions and the total number of interpretations made (large effect sizes). The frequency of endorsed negative interpretations correlated

**Table 1** Participants' demographic and clinical characteristics

	Patients with anorexia nervosa: mean (SD)	Healthy eaters: mean (SD)	Test value (df), significance
Age	26.7 (9.7) (range = 18–58)	27.5 (3.5) (range = 19–34)	$t(42) = -0.046$ , $p = .6$
Body mass index	14.3 (1.7) (range = 11.1–17.5)	21.3 (2.3) (range = 18.5–27.9)	$-13.4(60)$ , $p < .0001$
Length of illness (years)	10.6 (10.6) (range = 1–45)	N/A	N/A
SEED—anorexia nervosa severity index	2.1 (0.9)	N/A	N/A
DASS—depression	27.2 (12.5)	5.9 (6.4)	$8.802(52)$ , $p < .0001$
DASS—anxiety	21.1 (10)	3.6 (4.6)	$9.195(49)$ , $p < .0001$
DASS—stress	28.7 (8.5)	10.8 (9.7)	$7.866(62)$ , $p < .0001$
DASS—total	77.8 (25.9)	20.2 (18.6)	$9.732(62)$ , $p < .0001$
ARS-Q—rejection sensitivity	17.6 (6.6)	9 (4.7)	$5.955(63)$ , $p < .0001$

SEED, Short Evaluation of Eating Disorders; DASS, Depression Anxiety Stress Scale; ARS-Q, Adult Rejection Sensitivity Questionnaire.

positively not only with symptoms of anxiety and depression but also with fear of weight gain and body image disturbance, symptoms that specifically define the core eating disorder psychopathology of anorexia nervosa.

The finding of a negative interpretation bias of ambiguous social situations in anorexia nervosa is similar to what has been found in people with symptoms of anxiety or depression (Hirsch et al., 2016). For instance, previous research has found a similar effect size (i.e. large) for an interpretation bias to ambiguous social scenarios when high anxious people were compared with low anxious people (Huppert et al., 2007). A large effect size was also found in patients with depression compared with healthy volunteers when completing stem sentences in relation to the self and social encounters (Rusu, Pincus, & Morley, 2012). Therefore, a negative interpretation bias of social scenarios appears to be a transdiagnostic feature of several syndromes.

This study established the presence of interpretation biases in patients with anorexia nervosa by using a cross-sectional design. Findings also highlighted a correlation between these biases and core eating disorder symptoms (i.e. fear of weight gain and body image disturbance). The use of computerised trainings to modify negative interpretation bias would be able to test the causal role of this bias in maintaining core eating disorder symptoms (i.e. abnormal eating behaviours). Future longitudinal research could then examine the stability of this bias over time and its relation to disease course. Larger samples are needed to replicate these findings.

To conclude, the ethos of this work was on the transdiagnostic investigation of psychopathological traits. Indeed, the aim of this study was not to prove the specificity of rejection sensitivity to

eating disorders but to support the hypothesis that this feature might be relevant in anorexia nervosa, as well as other psychiatric conditions. Findings indicated that patients with anorexia nervosa report high levels of rejection sensitivity and endorse more negative and less neutral/positive interpretations of social scenarios that involve the risk of rejection than a group of healthy eaters. This tendency correlated positively not only with depression and anxiety but also with eating disorder symptoms. Interventions that directly target a negative interpretation bias to ambiguous social stimuli (i.e. cognitive bias modification trainings) or that aim at increasing self-compassion and reduce sensitivity to social threat (Goss & Allan, 2014) might result in a reduction of abnormal eating behaviours in anorexia nervosa.

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### Supporting information

Additional Supporting Information may be found in the online version of this article at the publisher's web site.

### **3.1. Chapter summary**

The aim of this study was to increase understanding of the cognitive processes that might underlie AN. The study showed that women with AN have high levels of rejection sensitivity and a negative interpretation bias for ambiguous social stimuli that include the risk of rejection in comparison to healthy eaters. Furthermore, this bias correlated with a fear of weight gain, body dissatisfaction, anxiety, and depression. Hence, women with eating disorders experience a negative interpretation bias supporting the notion that it is a transdiagnostic phenomenon (e.g., Hirsch et al., 2016). The implication of this chapter is that cognitive training approaches that directly target this mechanism might help to modify clinical symptoms. Consequently, the next chapter of this thesis will investigate whether CBM specifically targeted at rejection sensitivity can modify a negative interpretation bias in women with AN. It will also assess the effect of CBM training on other clinical symptoms (i.e., eating behaviour).

## Chapter four:

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### Study two

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#### **Based upon:**

**Turton, R.**, Cardi, V., Treasure, J., & Hirsch, C. (2018). Modifying a negative interpretation bias for social scenarios that depict the risk of rejection in women with anorexia nervosa, *Journal of Affective Disorders*, 227, 705-712.  
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#### **4.1. Abstract**

A heightened sensitivity to social rejection might contribute towards the interpersonal difficulties and symptoms that characterise AN. This paper examines the effect of Cognitive Bias Modification for Interpretation biases (CBM-I) training on a negative interpretation bias for ambiguous social scenarios that involve the risk of rejection and eating behaviour. Women with AN received a single session of CBM-I training to develop a more benign interpretational style or a control condition (which included 50:50 negative and benign resolutions). To measure participant's interpretation bias for social stimuli, a sentence completion task was used pre and post-training (a near-transfer outcome measure). A test meal was given after the training and salivary cortisol (stress) levels were measured as far-transfer outcome measures. CBM-I training led to a significant reduction in a negative interpretation bias in both conditions. No effect on eating behaviour or stress was found, which may be expected, as the training conditions did not significantly differ in interpretation bias change. The findings of this study suggest that it is possible to modify a negative interpretation bias for social stimuli. To clarify the effect of CBM-I training on AN symptomatology, repeated, more intensive, and ecologically-valid training interventions may be required. This is because any change in eating behaviour may not be immediate, particularly in a population with a low body mass index and long-illness durations.

#### **4.2. Introduction**

A priority for the eating disorders field is to increase understanding of the mechanisms that underpin these mental illnesses. Experimental psychopathology studies might help to address this matter by indicating whether a range of cognitive, behavioural, social, and neural processes have a causal role in symptomatology (Jansen, 2016). This endeavour may ultimately lead to the development of more precise and personalised treatments, which has been highlighted as one of the top ten research agendas for eating disorders (see van Furth, van der Meer, & Cowan, 2016). Theoretical models have suggested AN is associated with a range of interpersonal difficulties, including a heightened sensitivity towards social rejection. It is suggested that perceived/ actual social rejection might cause symptoms such as dietary

restriction and weight-loss to develop as a maladaptive means of trying to improve self-worth and social acceptance, as well as to reduce negative affect. However, the symptoms of AN can further isolate the individual and exacerbate their social difficulties (Arcelus et al., 2013; Atlas, 2004; Goss, & Gilbert, 2002; Reiger et al., 2010; Treasure & Schmidt, 2013).

Experimental studies have confirmed that people with eating disorders have a heightened sensitivity to social rejection (Cardi, Di Matteo, Corfield, & Treasure, 2013; Cardi, Di Matteo, Gilbert, & Treasure, 2014). One cognitive mechanism that might underlie this sensitivity to rejection in AN could be a negative interpretation bias for ambiguous social stimuli that involve the risk of rejection. This bias has been defined as a consistent tendency to resolve ambiguity in a negative manner (Hirsch, Meeten, Krahé, & Reeder, 2016). Indeed, Cardi et al. (2017) found that women with AN make more negative, and less benign, interpretations of ambiguous social scenarios that involve the risk for social rejection than healthy women. This negative bias was positively associated with a fear of weight gain and body dissatisfaction, as well as levels of depression and anxiety. However, causal influences could not be drawn due to the cross-sectional design of the study. Instead, approaches that modify this negative interpretation bias for social stimuli are needed to further elucidate its role in AN psychopathology and the clinical potential of targeting this bias (Treasure, Cardi, Leppanen, & Turton, 2015).

CBM-I is a computerised training task that aims to ameliorate a negative interpretation bias (e.g., Grey & Mathews, 2000; Mathews & Mackintosh, 2000). It typically involves listening to ambiguous scenarios that are resolved in a benign manner. Cardi et al. (2015) piloted a novel cognitive training approach for adult women with AN receiving inpatient care by combining CBM-I with an attention bias modification training task to target cognitive biases relating to social stimuli. Promisingly, five sessions of cognitive training was associated with a reduction in participant's negative interpretation and attention biases for social stimuli (with medium effect sizes). There was a significant decrease in participant's levels of self-reported anxiety (small effect size). Furthermore, they had increased levels of self-compassion in response to a video clip that involved receiving negative feedback from a supervisor (medium effect size).

Given the encouraging finding that the effect of CBM-I transferred to a self-report measure of sensitivity to social rejection in AN (Cardi et al., 2015), an interesting next step could be to examine whether facilitating a more benign interpretational style for social stimuli also has an influence on eating behaviour and a biological marker of interpersonal stress levels (salivary cortisol). The present study will test these hypotheses by comparing a single session of benign interpretation training to a control condition on ‘near-’ (i.e., bias change) and, if differential bias change is achieved, then the impact on ‘far-’ transfer (i.e., eating behaviour, salivary cortisol) outcome measures.

As previous research has focused on inpatients, it would also be of interest to examine the effect of CBM-I training for women from the community as well. This may be an important research gap because women in the community could potentially experience increased feelings of isolation in comparison to women in inpatient services who have continuous support from their treatment team and other service-users (e.g., Treasure, Crane, McKnight, Buchanan, & Wolfe, 2011).

The aim of this study was to examine the impact of a single session of CBM-I training on interpretation biases for social stimuli that depict the risk of rejection and other AN related symptoms in both inpatient and community women. It was hypothesised that a 100% dose of CBM-I training (experimental condition) would produce a significantly greater change in participants’ interpretation bias than a 50% dose (control condition). This was considered a ‘near-transfer’ outcome for CBM-I training. The study also included exploratory ‘far-transfer’ outcomes (i.e., effects on anxiety, salivary cortisol, and test meal consumption).

### **4.3. Method**

#### *4.3.1. Design*

A within-subjects design was used, with participants completing a single session of an experimental and control version of CBM-I training. The different versions of the training were completed during two separate sessions, which were scheduled one week apart. To reduce order effects, an AB/BA crossover design was used with the random allocation of participants to either the experimental/ control condition first (e.g., Suresh, 2011). A block randomisation approach was taken through the use of a random number generator in Microsoft Excel.

#### *4.3.2. Participants*

A total of 55 women with AN were recruited. This included 26 adult women from inpatient eating disorder services (i.e., from the Bethlem Royal Hospital ( $N = 18$ ), St Ann's Hospital ( $N = 6$ ) and Vincent Square's Eating Disorders Service ( $N = 2$ )) and 29 adult women from the community. The study was advertised online by King's College London and a national eating disorders charity called BEAT ([www.beat.co.uk](http://www.beat.co.uk)). Participants were told that the study is, 'looking to learn more about how people with AN relate to social scenarios' and, 'computer brain training tasks in eating disorders'.

Eligibility criteria for the study included: a diagnosis of AN based upon DSM-5 criteria (American Psychiatric Association, 2013), an age range between 18 and 65, no current substance abuse, no neurological condition, no acute suicidality and no severe co-morbidity, such as psychosis. Participants were screened using the Structured Clinical Interview for the Diagnostic and Statistical Manual of Mental Disorders – fifth edition (American Psychiatric Association, 2013). An NHS Research Ethics Committee gave approval for the study (reference number, 14/LO/2166).

#### 4.3.3. *Materials*

##### 4.3.3.1. Questionnaires

##### Eating Disorders Examination Questionnaire (EDEQ)

The EDEQ (Fairburn & Beglin, 1994) measures participants eating psychopathology based upon their cognitions and behaviour over the previous 28 days. It has four subscales: weight concerns, shape concerns, dietary restraint, and eating concerns and gives an overall total score. The EDEQ has been found to be both a reliable (Luce & Crowther, 1999) and valid measure (Mond et al., 2004). The Cronbach's alpha for the weight concerns subscale = .8; shape concerns = .88; dietary restraint = .86; eating concerns = .8; total score = .95.

##### Depression Anxiety Stress Scales (DASS-21)

This 21-item questionnaire was developed by Lovibond and Lovibond (1995) and assesses participants' levels of depression, anxiety and stress during the past week. The measure has been reported to have good internal consistency and concurrent validity (Antony et al., 1998; Henry & Crawford, 2005). The Cronbach's alpha for the depression subscale = .91; anxiety = .88; stress = .87; total score = .94.

##### Adult Rejection Sensitivity-Questionnaire (ARS-Q)

The ARS-Q (Downey & Feldman, 1996) consists of nine scenarios that depict the risk for social rejection. For each scenario, participants are instructed to rate their levels of anxiety related to it and how likely they would expect to be rejected. The measure has been found to have satisfactory psychometric properties (Berenson et al., 2011). The Cronbach's alpha for the total score = .82.

##### Work and Social Adjustment Scale (WSAS)

This five-item self-report measure was developed by Marks (1986) and can be used to assess the level of impairment an identified problem causes to work and social functioning. The WSAS has been reported to be both a reliable (Zahra et al., 2014)

and valid psychometric measure (Mundt, Marks, & Shear, 2002). The Cronbach's alpha for the total score = .86.

#### 4.3.3.2. Computer tasks

##### Sentence completion task

This task was adapted from Cardi et al., (2015), Hayes et al., (2010) and Huppert et al., (2007). Following a brief practice of the task participants completed 10 stem-sentences, which describe hypothetical ambiguous social scenarios that involve the potential for social rejection (e.g., *"You message your close friend, it's been four hours and they haven't replied yet, you think that they are..."*). The scenarios are presented on a computer screen and over headphones with the instruction to write down as many completions to the scenarios as possible and in the order that they come to mind. For each scenario participants are also asked to place an asterix alongside the completion that they believe would **best** complete the scenario.

In order to examine whether the CBM-I training had an effect on participant's interpretation bias, responses on the sentence completion task were rated by two research assistants (S.D. and L.D.) as being negative or benign completions. The raters were blind to the treatment allocation of the participants. There was high inter-rater reliability for their ratings (Cohen's kappa = .86). A third independent researcher (J.L.) resolved any discrepancies in their ratings.

##### CBM-I training

This cognitive training task was modified from Hirsch et al., (2009) and Cardi et al., (2015). Participants were instructed to listen over headphones to socially ambiguous scenarios that depict the risk of social rejection until the final word, which then resolves the scenario with either a negative, or benign completion (e.g., *"it is the night before your first day at a new job and you do not know many people within the company. When you arrive in the morning you think that you will be... welcomed"*). This was then followed by a comprehension question, which reinforced the

completion to the ambiguous scenario (e.g., do think that your new colleagues will be pleased to meet you?), which has either a ‘yes’ or ‘no’ response (i.e., the letters ‘Q’ or ‘P’ on the keyboard respectively). A ‘correct’ or ‘incorrect’ feedback message and sound was given onscreen and over the headphones for 1000ms. Participants were instructed to answer this question based upon the information that they heard within the scenario and what might follow on from it, even if this was not necessarily how they might respond within the situation itself.

In the experimental condition, participants were presented with 90 ambiguous social scenarios that always had a benign completion and a comprehension question that reinforced this. The scenarios covered a wide range of everyday social scenarios relating to family, friendships, romantic relationships, education, work, leisure activities, and social media use. Participants were also presented during the task with 10 test ambiguous social scenarios that did not have any resolution but were followed by a ‘yes’ or ‘no’ question. These ‘catch trials’ were used to assess participant’s interpretational style during the course of the training. Altogether, the scenarios were presented in five blocks with each block containing 18 modification trials and 2 test trials given in a random order. Between each block participants were given a short message telling them their progress during the task and encouraging them to have a short break should they wish to.

In the control condition, a similar procedure was used with the only difference being that half of the 90 ambiguous social scenarios had a negative completion with the other half having a benign resolution (45 of the trials).

#### 4.3.3.3. Visual Analogue Scales (VASs)

A self-report questionnaire using VASs (i.e., 10cm long) was used to determine participant’s state levels of hunger (at baseline only; anchored by “not hungry at all” and “extremely hungry”), anxiety (anchored by “not anxious at all” and “extremely anxious”), and mood (anchored by “extremely low” and “extremely high”).

#### 4.3.3.4. Salivary cortisol levels

Saliva samples were collected using Salivettes<sup>®</sup> (Sarstedt). These were analysed for their cortisol concentration by the Biochemistry department at King's College London. This was to provide an objective measure of participants stress levels following the CBM-I training. Community women were all scheduled to take part at 11am and inpatients were scheduled to take part in the study at 3.30pm.

#### 4.3.3.5. Filler task

##### The speed of comprehension test

Following the training participants completed the speed of comprehension test (Baddeley, Emslie & Nimmo-Smith, 1992) as a filler task to lower the chance of group differences in mood influencing the test meal. The use of the filler task is in line with the protocols of previous CBM-I research (e.g., Hayes et al., 2010). The task involves giving to participants a list of 80 sentences, half being true and half being false (e.g., *trees are vehicles*), and asking them to place a tick next to the true sentences and a cross next to the false sentences. Participants are told that speed is not important for the task. The test was adapted for this study by removing any sentences related to food or eating.

#### 4.3.3.6. Eating behaviour

##### Test meal: the smoothie challenge task

A choice of three smoothie drinks were presented to participants as purchased in the bottle (250ml each). The smoothie drink flavours were: '*kiwi, apples and lime*', '*mangoes and passion fruits*', and '*strawberries and bananas*'. Participants were asked to choose one of the smoothies and were then asked to drink as much as they felt able and comfortable to during a five-minute period. The amount of smoothie consumed was measured.



#### 4.3.4. Procedure

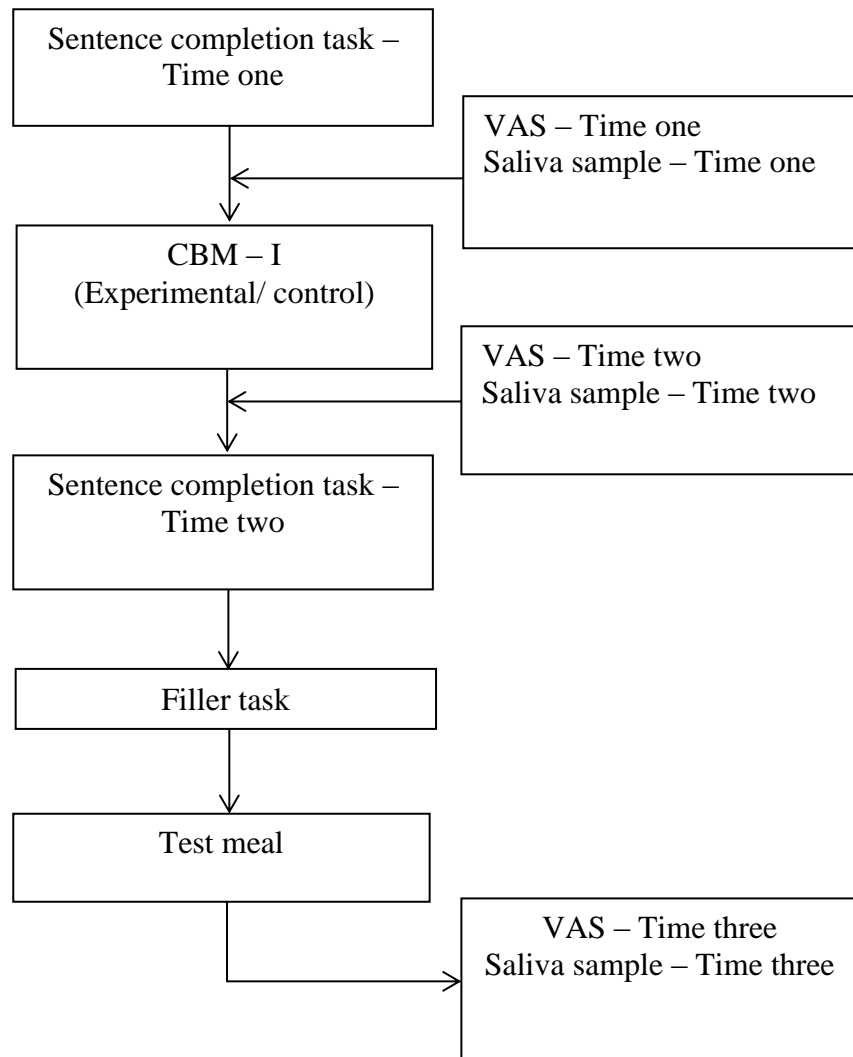
Participants completed a set of baseline questionnaires prior to taking part in the study using [www.surveymonkey.net](http://www.surveymonkey.net). This included a demographics questionnaire, the EDEQ, DASS-21, ARS-Q, and WSAS. Participants were informed that they should consume something to eat 1.5/2hours prior to the study and to then not eat anything until the time of the study, though drinking water was fine before both sessions.

The testing took place at the inpatient sites or at King's College London. At the beginning of the first session participant's completed the sentence completion task on a laptop with the task programmed on E-Prime, version two. This was followed by a baseline set of VASs and a saliva sample (time point one: T1) and either the experimental/ control version of the CBM-I training on the laptop depending on which condition they were randomly allocated to for the first session. After the training, participants completed the VASs and gave a saliva sample again (time point two: T2) and the sentence completion task post-training to assess participants interpretational style. A different set of ambiguous stem sentences were presented post-training. The filler task was then given to participants, followed by the smoothie challenge task. For inpatients the smoothie was in place of their afternoon snack on the ward. Participants then completed the final set of VASs and gave a saliva sample (time point three: T3).

In the second session, a similar procedure to the first session was completed with participants doing a different version of the CBM-I training, depending on what they did in the first session (i.e., either the experimental/ control condition). A different set of ambiguous scenarios were also used in the sentence completion task in the second session. Please see **figure 1.** for an overview of the studies procedure.

### Study outline

Repeated one week apart using a within-subjects design



**Figure 1.** This flow-chart shows an outline of the procedure. This design was repeated over two sessions in total. Abbreviations: CBM-I = Cognitive Bias Modification for Interpretation biases; VAS = Visual Analogue Scale.

#### 4.3.5. *Statistical analyses*

A mixed effects linear model (bootstrapped at 500 repetitions) using Stata version 14<sup>®</sup> (StataCorp, 2015) and the `mepoisson` command was used to analyse the frequency of negative and benign ‘best’ responses on the sentence completion task (i.e., the ending that participants thought would best resolve the ambiguous scenario). The predictors included in the model were patient group (i.e., inpatient or community women with AN), training condition (i.e., experimental or control CBM-I), time point (i.e., pre or post CBM-I training), and interpretation valence (i.e., negative or benign). A series of mixed effects linear models (bootstrapped at 1000 repetitions) were performed to investigate the CBM-I training task data, VAS responses, stress levels as measured salivary cortisol levels and smoothie challenge task data. As the study used a repeated measures design, effect sizes were calculated as Standardised Mean Change (SMC) scores (e.g., Morris & DeShon, 2002) for the primary outcome measures (i.e., the catch trials, sentence completion task and taste test). SMC effect sizes were calculated for each training condition and are understood as small ( $\Rightarrow .2$ ), moderate ( $\Rightarrow .5$ ) and large ( $\Rightarrow .8$ ).

### 4.4. Results

#### 4.4.1. *Participant characteristics*

Please see **table 1.** for an overview of the demographic and clinical characteristics of the women with AN. Also, almost half ( $N = 24$ ) had comorbidity with anxiety disorder or depression and ( $N = 26$ ) were taking antidepressant medications at the time of the study. The community women with AN were significantly older than the inpatients with AN, and had longer illness durations and greater levels of eating disorder psychopathology (i.e., on the EDEQ restraint, eating concern, and total scales). Participants’ baseline levels of hunger, anxiety, and mood did not significantly differ between the experimental and control conditions (all  $p > .05$ ).

	Total sample ( <i>N</i> = 55)	Inpatient women ( <i>N</i> = 26)	Community ( <i>N</i> = 29)	Test statistic
	Mean (SD)	Mean (SD)	Mean (SD)	Significance
Age	28.5 (10.7)	25.2 (8.5)	31.48 (11.8)	$t = -2.29, p = .026$
Years of education	16.5 (2.8)	15.7 (2.3)	17.1 (3)	$t = -1.84, p = .07$
BMI	15.4 (1.6)	15.1 (1.15)	15.8 (2)	$t = -1.55, p = .129$
Illness duration (years)	10.9 (9.1)	8 (7.8)	13.4 (9)	$t = -2.18, p = .034$
EDEQ - Restraint	3.2 (1.8)	2.5 (1.77)	3.9 (1.7)	$t = -2.97, p = .004$
EDEQ - Eating Concern	3.3 (1.6)	2.7 (1.5)	3.7 (1.5)	$t = -2.46, p = .017$
EDEQ - Weight concern	3.6 (1.6)	3.2 (1.6)	3.9 (1.5)	$t = -1.69, p = .097$
EDEQ - Shape concern	4.1 (1.4)	3.9 (1.5)	4.3 (1.4)	$t = 1.01, p = .316$
EDEQ - Total	3.5 (1.5)	3.1 (1.5)	4 (1.43)	$t = -2.23, p = .03$
DASS - Stress	24.1 (10.4)	22.7 (9.9)	25.4 (10.7)	$t = -.96, p = .342$
DASS - Depression	22.3 (11.4)	20.5 (10.5)	23.9 (12.2)	$t = -1.1, p = .28$
DASS - Anxiety	15.3 (11)	13.4 (9.2)	17.1 (12.2)	$t = -1.26, p = .212$
DASS - Total	61.8 (29.2)	56.6 (25.2)	66.4 (32)	$t = -1.25, p = .217$
WSAS	24.6 (9)	24.8 (8.2)	24.4 (9.7)	$t = .175, p = .86$
ARS-Q	14.9 (6.6)	13.8 (7)	15.8 (6.3)	$t = -1.12, p = .267$

**Table 1.** This shows the demographic and clinical characteristics for the women with AN. Abbreviations: BMI = Body Mass Index; EDEQ = Eating Disorders Examination Questionnaire; DASS = Depression Anxiety Stress Scale; WSAS = Work Social Adjustment Scale; ARS-Q = Adult Rejection Sensitivity-Questionnaire.

#### 4.4.2. CBM-I training task data

##### 4.4.2.1. Accuracy on the comprehension trials

Accuracy levels on the comprehension trials were analysed using a 2x2 mixed effects linear model (i.e., patient group x training condition) which showed a significant main effect of patient group ( $X^2(1) = 11.63, p = .0006$ ) and training condition ( $X^2(1) = 4.22, p = .04$ ).

Pairwise comparisons showed that the inpatient women with AN were significantly more accurate on the comprehension trials ( $M = 82.46, SD = 8.68$ ) than the community women with AN ( $M = 76.21, SD = 16.06; Z = 3.41, p = .001$ ). Also, participants were significantly more accurate in the experimental ( $M = 81.37, SD = 13.88$ ) versus control condition ( $M = 77.05, SD = 12.62$ ) on the comprehension trials ( $Z = 2.05, p = .04$ ). There was no significant interaction between patient group and training condition ( $X^2(1) = .04, p = .837$ )<sup>†</sup>.

##### 4.4.2.2. Catch trial responses

A 2x2 mixed effects linear model (i.e., patient group x training condition) did not find a significant main effect of patient group ( $X^2(1) = .55, p = .46$ ) or training condition ( $X^2(1) = .79, p = .374$ ) or interaction between these predictors ( $X^2(1) = .19, p = .66$ ) on the number of benign responses made on the catch trials (experimental condition  $M = 6.13, SD = 2.04$ , control condition  $M = 5.83, SD = 1.91$ ; SMC effect size: negligible to small = .14).

#### **4.4.3. ‘Near-transfer’ outcome measures**

##### *4.4.3.1. Sentence completion task (‘Best’ interpretations)*

A 2x2x2x2 mixed effects linear model (i.e., patient group x training condition x time point x valence) showed there was a significant interaction between patient

group and valence for the frequency of ‘best’ interpretations ( $X^2(1) = 32.36, p < .001$ ). Subsequent pairwise comparisons showed that the community women with AN made significantly more negative ‘best’ interpretations ( $M = 5.76, SD = 2.66$ ) than the inpatient women with AN ( $M = 4.15, SD = 2.54; Z = 4.14, p < .0001$ ). They also made less benign ‘best’ interpretations ( $M = 4.15, SD = 2.62$ ) than the inpatient women with AN ( $M = 5.66, SD = 2.56; Z = -4.12, p < .0001$ ).

There were no significant main effects or interactions involving the predictor training condition (all  $p > .05$ ) (please see **supplementary item 1**. for the individual test results. This suggests that the experimental and control conditions did not significantly differ in terms of interpretation bias change. Instead, there was evidence that both conditions reduced interpretation bias. This was indicated by a significant interaction between time point and valence ( $X^2(1) = 19.76, p < .001$ ). In both conditions participants made significantly less negative ‘best’ interpretations post-training ( $M = 4.4, SD = 2.66$ ) than pre ( $M = 5.6, SD = 2.65; Z = -2.89, p = .004$ ). They also made more benign ‘best’ interpretations post-training ( $M = 5.4, SD = 2.64$ ) than pre training ( $M = 4.33, SD = 2.65; Z = 3.02, p = .003$ ).

To help aid the development of future studies effect sizes were calculated for the change in interpretation bias. A moderate to large effect size was found in the experimental condition for the reduction in a negative interpretation bias (SMC effect size =  $-.66$ ) versus a small to moderate effect size in the control condition (SMC effect size =  $-.42$ ). Please see **table 2**. for the means and effect sizes per training condition and patient group.

		<u>Experimental condition</u>			<u>Control condition</u>		
Sentence completion task (‘Best’ completions)		<u>Pre CBM-I</u> M (SD)	<u>Post CBM-I</u> M (SD)	<u>SMC</u> (95% CI)	<u>Pre CBM-I</u> M (SD)	<u>Post CBM-I</u> M (SD)	<u>SMC</u> (95% CI)
Total sample (N = 55)	Negative interpretations	5.47 (2.65)	4.05 (2.72)	-.66 (-.37, -.95)	5.73 (2.68)	4.74 (2.59)	-.42 (-.15, -.7)
	Benign interpretations	4.45 (2.62)	5.85 (2.7)	.66 (.37, .95)	4.2 (2.7)	4.94 (2.53)	.3 (.04, .59)
Inpatient women  (N = 26)	Negative interpretations	4.69 (2.59)	3.23 (2.64)	-.56 (-.15, -.98)	4.46 (2.5)	4.23 (2.32)	-.09 (-.3, .47)
	Benign interpretations	5.15 (2.56)	6.65 (2.61)	.58 (.16, 1)	5.42 (2.59)	5.42 (2.37)	.00 (-.38, .38)

		Pre	Post	SMC	Pre	Post	SMC
Community women (N = 29)	Negative interpretations	6.17 (2.55)	4.79 (2.61)	-.78 (-.37, -1.2)	6.86 (2.33)	5.21 (2.77)	-.85 (-.43, -1.28)
	Benign interpretations	3.83 (2.55)	5.14 (2.63)	.78 (.36, 1.19)	3.1 (2.33)	4.52 (2.63)	.69 (.28, 1.09)

**Table 2.** This shows the mean frequency of participant’s negative and benign ‘best’ responses on the sentence completion task pre and post cognitive bias modification training. Abbreviations: M = Mean; SD = Standard Deviation; SMC = Standardised Mean Change; CBM-I = Cognitive Bias Modification for Interpretation biases.



#### 4.4.3.2. Visual analogue scales

##### 4.4.3.2.1. Anxiety ratings

A 2x2x2 mixed effects linear model (i.e., patient group x training condition x time point) showed that there was a significant main effect of time point on participants anxiety ratings ( $X^2(2) = 21.01, p < .001$ ). Pairwise comparisons showed that in both conditions there was no significant difference in anxiety ratings between pre (T1) ( $M = 4.63, SD = 2.71$ ) and post (T2) training ( $M = 4.82, SD = 2.51; Z = .77, p = .441$ ). Anxiety ratings post smoothie challenge task (T3) ( $M = 5.72, SD = 2.78$ ) were significantly greater than at T2 ( $Z = 3.79, p < .0001$ ) and T1 ( $Z = 4.25, p < .0001$ ). There was no significant main effect of patient group ( $X^2(1) = 3.69, p = .0549$ ), training condition ( $X^2(1) = .44, p = .508$ ), or interactions between these predictors (all  $p > .05$ ).

##### 4.4.3.2.2. Mood ratings

A 2x2x2 mixed effects linear model (i.e., patient group x training condition x time point) showed that there was a significant main effect of time point on participants mood ratings ( $X^2(2) = 11.52, p = .0032$ ). Pairwise comparisons showed that in both conditions mood ratings were significantly lower post training (T2) ( $M = 3.76, SD = 2.02$ ) than pre training (T1) ( $M = 4.23, SD = 1.82; Z = -2.83, p = .005$ ). Mood ratings post smoothie challenge task (T3) ( $M = 3.65, SD = 2.22$ ) were significantly lower than T1 ( $Z = -3.13, p = .002$ ). There was no significant difference between T3 and T2 ( $Z = -.66, p = .51$ ). There was no significant main effect of patient group ( $X^2(1) = .07, p = .7933$ ), training condition ( $X^2(1) = 1.14, p = .287$ ), or interactions between these predictors (all  $p > .05$ ).

#### 4.5. 'Far-transfer' outcome measures

There were no significant differences between training conditions on the interpretation bias near transfer task. Given this, one would not anticipate any significant differences on the far transfer measures since the key mechanism was not differentially changed. The results below are reported for completeness.

##### 4.5.1. Test meal: Smoothie consumption

A 2x2 mixed effects linear model (i.e., patient group x training condition) showed that there were no significant main effect of patient group ( $X^2(1) = 1.6, p = .2057$ ) or training condition ( $X^2(1) = .02, p = .8814$ ) or interaction between these predictors ( $X^2(1) = .3, p = .58$ ) on smoothie consumption (measured in milliliters) (experimental condition:  $M = 68.65, SD = 90.65$ , control condition:  $M = 67.47, SD = 87.17$ ; SMC effect size: negligible = .02).

##### 4.5.2. Salivary cortisol levels

A 2x2x3 mixed effects linear model (i.e., patient group x training condition x time point) showed that there was a significant main effect of patient group ( $X^2(1) = 152.65, p < .0001$ ). Post-hoc pairwise comparisons showed that the community women had higher levels of salivary cortisol ( $M = 7.58, SD = 4.76$ ) than the inpatient women with AN ( $M = 5.13, SD = 2.26; Z = 12.36, p < .0001$ ). This finding is to be expected as the community women with AN were tested in the morning when cortisol levels are naturally higher. There was no significant main effect of training condition ( $X^2(1) = 1.46, p = .23$ ), time point ( $X^2(2) = 2.34, p = .31$ ), or interactions between these predictors (all  $p > .05$ ). Please see **supplementary item 2**. for the means per training condition.

## 4.6. Discussion

This study hypothesised that a 100% dose of CBM-I training (experimental condition) would produce a significantly greater change in participants' interpretation bias for ambiguous social stimuli that depict the risk of rejection in comparison to a 50% dose (control condition). The study also included exploratory hypotheses (i.e., there would be effects of the training on anxiety, salivary cortisol and test meal consumption). The study found that participants made significantly less negative and more benign 'best' (endorsed) interpretations after both training conditions. Given that the experimental and control conditions did not significantly differ in terms of the reduction in interpretation bias for social stimuli, one would not expect differential effects on far transfer to 'symptoms'. In keeping with this, there were no significant effects on anxiety, eating behaviour or stress (salivary cortisol levels) after a single session of training.

The findings of this study suggest that it may be possible to modify a negative interpretation bias for social stimuli in AN using both a 100% (experimental condition) and 50% dose (control condition) of CBM-I training. An exploratory analysis of effect sizes indicated that there was some evidence for a greater reduction in negative interpretation bias in the experimental versus control condition (experimental condition SMC effect size =  $-.66$ , versus control condition SMC effect size =  $-.42$ ). A possible explanation for the reduction in a negative interpretation bias for social stimuli in both training conditions might be that the control condition also included benign resolutions for half of the CBM-I trials (50%). This lower dose of the training in the "control" condition may have been sufficient to modify participant's interpretational style. The effect of both training conditions is also potentially evidenced by participants giving benign responses to more than half of the catch trials in both training conditions (experimental  $M = 6.13$ , control  $M = 5.83$ ).

Another noteworthy finding from this study was that overall the community women with AN had a significantly greater negative interpretation bias for social stimuli than the inpatient women with AN. This could be due to their longer illness durations and higher levels of eating disorder psychopathology. This supports the hypothesis that

women in the community with AN may have increased sensitivity to social rejection, perhaps due to being more isolated than inpatients.

A limitation of this study is that inpatient and community participants were tested at an alternate time in order to fit with ward timetables. Also, the test meal procedure did not involve ambiguity, meaning that it may be regarded as quite a considerable far-transfer outcome measure for a single session of CBM-I training. Particularly given that the population recruited in the present study had a low body mass index ( $M = 15.4$ ) and long-illness durations ( $M = 10.9$  years), meaning that a single session CBM-I training may not produce an immediate effect on core symptoms such as eating behaviour. A question for future endeavours could be to clarify the boundary of any training effect, by using far- transfer outcome measures that are more aligned with the primary aim of the training (reducing sensitivity to social rejection in situations that are open to multiple interpretations).

#### **4.6.1. Future research directions**

In order to produce larger effects on interpretation bias and other AN related symptoms multiple training sessions ( $N = 6$ ), as used in the case series by Cardi et al. (2015), are probably needed. Particularly, as people with AN show decreased learning from feedback in both the acute state and after weight restoration (Foerde & Steinglass, 2017). This may explain why participant's accuracy scores on the comprehension trials were lower than those previously reported in other populations (e.g., Hayes et al. (2010) reported that people with generalised anxiety disorder were accurate on 92.5% of the comprehension trials in the active condition).

Krahé, Mathews, Whyte, & Hirsch (2016) have recently developed a novel control condition for CBM-I research, that may be considered more 'neutral' than the one used in the present study. This involves CBM-I trials keeping their neutrality entirely, instead of being given a negative or benign meaning (e.g., "*You add a new colleague at work on a social networking website but it's been several hours and they haven't approved your request yet. Thinking about it that evening, you wonder whether they will accept your friend request*"). This approach has been shown to be effective in a multi-session training study for people with affective disorders (i.e., the control

differs from active CBM in terms of change in bias and outcome of emotion) (Hirsch et al., submitted). Therefore, it may be beneficial for future research to also use this control condition in eating disorders.

In the present study mood was found to decrease following both CBM-I training conditions, perhaps due to participant fatigue. This effect was not found by Cardi et al. (2015), and may have confounded any possible impact of the training on eating behaviour and stress levels meaning that this needs to be addressed in future studies. To make the training more engaging, one possibility is to have shorter training sessions. Another approach could be to also use alternate interpretation training paradigms such as homograph training, which involves repeatedly pairing homographs (e.g., row) with non-threat (e.g., a boat) as opposed to threat related (e.g., argument with a friend) words (see Hirsch et al., 2016 for an overview).

The present study focused on rejection sensitivity in response to social situations. A recent study by De Paoli, Fuller-Tyszkiewicz, Halliwell, Puccio and Krug (2017) found that appearance-based rejection sensitivity mediates the relationship between insecure attachment styles and disordered eating in an eating disorder sample (AN, bulimia nervosa and binge eating disorder). Given that previous research has also suggested an association between negative interpretation bias and body dissatisfaction (Cardi et al., 2017), it would be of interest to adapt CBM-I training materials to also target appearance-based rejection sensitivity in future research.

#### **4.6.2. Implications**

CBM-I training primarily targets ‘automatic’ thought processes, whereas traditional talking therapies are more focused on ‘reflective’ processes. Therefore, future work could test whether using CBM-I alongside therapeutic interventions such as cognitive behavioural or interpersonal psychotherapy has additive effects. For instance, with the support of a therapist goal-setting approaches may help patients to translate their learning from CBM-I into ‘real life’ situations.

## 4.7. Conclusion

Following CBM-I women with AN made significantly less negative ‘best’ interpretations for ambiguous social stimuli that depict the risk of rejection after one session of both training conditions. There were negligible effects on other AN related symptoms (anxiety and eating behaviour), which may be expected given that the training conditions did not significantly differ in interpretation bias change. In future research multiple sessions of training and far-transfer outcome measures that are closer to the primary aim of the training (reducing sensitivity to social rejection in ambiguous situations) may be used to establish the boundary of the CBM-I training effect in AN and the clinical potential of modifying this bias.

### Footnote:

<sup>†</sup> A total of 28 participants ( $N = 15$  inpatients and  $N = 13$  community women) had accuracy scores over 90% on the comprehension trials in both the experimental and control conditions. For this group of participants, post-training there were trends for participants to make less negative ( $Z = -1.94$ ,  $p = .052$ ) and more benign interpretations ( $Z = 1.73$ ,  $p = .084$ ) than pre training in both conditions. There were no significant differences between conditions in the catch trial responses or test meal consumption ( $p > .05$ ).

## 4.9. Chapter summary

Based on the finding of chapter one that women with AN have a negative interpretation bias for social stimuli that depict the risk of rejection, this chapter targeted this bias by testing the effect of a single session of CBM-I training in comparison to a control condition (a 50% dose of training). It found that both training conditions significantly reduced a negative interpretation bias for social stimuli. Negligible effects on other AN related symptoms including anxiety, stress and eating behaviour were found, which may be predicted given that the training conditions did not significantly differ in interpretation bias change. The implication of this work is

that for adults with AN, multiple sessions of training with alternate control conditions may be needed to examine the effect of CBM-I on symptomatology. Furthermore, far-transfer outcome measures that are more aligned with the main goal of the training (reducing sensitivity to social rejection in ambiguous situations) are needed to clarify the boundary of the training effect.

An interesting finding from this chapter was that community women with AN had a greater negative interpretation bias for social stimuli than inpatient adults. This suggests that some groups of people with AN may be more vulnerable to this cognitive bias than others. In line with this suggestion, the next chapter of this thesis investigates whether adolescents with AN have a negative interpretation bias, as this age group may be particularly sensitive to social rejection. In addition, it tests the clinical potential of modifying this bias through CBM-I training and builds upon the design of the present chapter, by using the Cyberball task as a far transfer outcome. This measure may be more closely related to the primary aim of the training (to reduce rejection sensitivity).

## Chapter five:

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### Study three

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## **Cognitive bias modification for negative interpretations of social stimuli that depict the risk of rejection in adolescents with AN**

### **5.1. Abstract**

Adolescents with AN report a range of interpersonal challenges, including a heightened sensitivity to social rejection. A negative interpretation bias for ambiguous social stimuli that involve the risk of rejection might underlie these difficulties. The aim of this study was to test this hypothesis by investigating the effect of a single session of CBM-I training on rejection sensitivity in comparison to a control condition. Female adolescents ( $N=24$ ) with AN were recruited from an inpatient eating disorder unit. A within-subjects design was used. The near transfer outcome measure was a sentence completion task given pre- and post- training to examine interpretation bias change. The far transfer outcome measure was a social exclusion paradigm (Cyberball task) to measure sensitivity to social rejection. The experimental CBM-I training significantly reduced negative interpretation bias ( $r = .42$ ; moderate to large effect size), and there was a trend ( $r = .24$ ; small to moderate effect size) for self-esteem to be higher following rejection in the Cyberball task in comparison to the control condition. These findings demonstrate that cognitive bias modification can remediate a negative interpretation bias for social stimuli and possibly build resilience in response to social ostracism. Thus, further research to optimise this training approach may be of benefit for adolescents with AN.

### **5.2. Introduction**

A paradox of adolescence is that it is a time of emerging independence and self-identity in the context of a heightened sensitivity towards social rejection (Dechristé, Bursztein, & Ebtinger, 1990; Somerville, 2013). Studies using a Cyberball task (a virtual ball-throwing game designed to elicit social exclusion, Williams, Cheung & Choi, 2000) show that adolescents are more sensitive to rejection than adults, evidenced by elevated affective, and neural responses (Sebastian, Viding, Williams & Blakemore, 2010; Sebastian et al., 2011). AN predominately develops in females during this stage of development (Smink, Hoeken, & Hoek, 2012), with the

primary symptoms being self-starvation, low-weight, and distorted body image (American Psychiatric Association, 2003). Interpersonal difficulties are hypothesised to be a key risk and maintenance factor for the illness (e.g., Arcelus et al., 2013; Atlas, 2004; Goss, & Gilbert, 2002; Reiger et al., 2010; Treasure & Schmidt, 2013). This was exemplified by a recent qualitative study in adolescent inpatients with AN, which highlighted difficulties in group belonging (an impoverished social network), social sensitivity (rejection sensitivity), self-monitoring (fear of negative evaluation), and limited coping strategies for these interpersonal challenges (Patel, Tchanturia, & Harrison, 2016). Similar social difficulties have also been reported by adults with AN (Cardi, Mallorquí-Bagué, Albano, Monteleone, Fernández-Aranda, & Treasure, submitted).

Cognitive biases may be a mechanism that underlies social difficulties in AN. For instance, Cardi et al. (2017) found that women with AN produce more negative interpretations of ambiguous social scenarios that have the potential of social rejection than healthy women. This bias correlated with anxiety and depression and AN symptoms, including a fear of weight-gain and distorted body image. One theory is that a negative interpretation bias for social stimuli could increase the likelihood of perceiving/ experiencing social rejection, which in turn causes eating disorder symptoms as a maladaptive coping strategy (e.g., Rieger et al., 2010). Modifying the negative interpretation bias and examining the effect on rejection sensitivity can test this hypothesis. This is in line with the call for more experimental psychopathology studies in eating disorders (Jansen, 2016).

CBM-I is a computerised training approach whereby ambiguous scenarios are followed by benign resolutions (Grey & Mathews, 2000; Mathews & Mackintosh, 2000). Cardi et al. (2015) tested the feasibility of CBM for remediating both interpretation and attention biases towards social stimuli in a sample of adult inpatients with AN. Post-training (five sessions), participants made fewer negative interpretations of ambiguous social stimuli and demonstrated a medium sized increase in attending to socially accepting stimuli (smiling faces). Participants also reported lower levels of anxiety (as measured by the Depression Anxiety and Stress Scales; Lovibond, & Lovibond, 1995) and higher levels of self-compassion in response to a judgemental video clip. These encouraging findings showed the feasibility of CBM

training in adults with AN. However, research has not yet investigated an interpretation bias in adolescents with AN, or established whether it is possible to modify social sensitivity through CBM-I. This may be considered an important research gap due to the saliency of rejection sensitivity in this age group. Furthermore, adolescent inpatients with AN have reported that they would find ways of reducing social sensitivity beneficial (Patel, Tchanturia, & Harrison, 2016).

The aim of this study was to examine the effectiveness of CBM-I in reducing sensitivity to social rejection in adolescents with AN. It was hypothesised that an experimental condition of CBM-I training (100% dose of benign training) will reduce a negative interpretation bias for ambiguous social stimuli in adolescents with AN, and also increase resilience to social rejection in response to a Cyberball task, in comparison to a control version of CBM-I (50% dose of benign training).

### **5.3. Method**

#### *5.3.1. Participants*

Twenty-four female participants with AN were recruited from a child and adolescent mental health inpatient unit for eating disorders. Inclusion criteria for the study were: females between the ages of 14 and 18 years old, a diagnosis of AN based upon DSM-5 criteria (American Psychological Association, 2013), and fluency in English. Participants were told that the study was using a computer program to examine how adolescents with AN think about social scenarios. NHS research ethics granted approval for the study (14/LO/2166).

#### *5.3.2. Design*

A repeated measures design was used, with all participants completing an experimental and control version of CBM-I. The two versions of the training were completed on different days with the two sessions arranged one week apart from another (the order of the conditions was randomised using the random number generator function in Microsoft Excel<sup>®</sup>; e.g., Vickers, 2006).

### 5.3.3. *Materials*

#### 5.3.3.1. Questionnaires

##### Eating Disorders Examination Questionnaire (EDEQ; Fairburn & Beglin, 1994)

This measure assesses eating behaviour over the past 28 days through a self-reported questionnaire. It consists of four subscales (i.e., eating concern, shape concern, weight concern, and dietary restraint) with a global scale included also. The EDEQ has good internal consistency, convergent validity and test–retest reliability (Passi, Bryson & Lock, 2003; Mond, Hay, Rodgers, Owen & Beumont, 2004). The Cronbach’s alpha in this study was strong for the EDEQ total (.88).

##### Revised Children’s Anxiety and Depression Scale (RCADS; Chorpita, Yim, Moffitt, Umemoto & Francis, 2000)

This 47-item questionnaire assesses symptoms of anxiety and depression. Items are rated on a 4-point likert scale, ranging from 0 (“never”) to 3 (“always”). It produces a total anxiety scale and a scale for major depression. The RCADS is a valid and reliable questionnaire for a multi-ethnic late childhood population (Kösters, Chinapaw, Zwaanswijk, van der Wal, & Koot, 2015). The Cronbach’s alphas were strong (Total anxiety scale = .95; Major depression scale = .84).

##### Children’s Rejection Sensitivity Questionnaire (CRSQ; Downey, Lebolt, Rincon, & Freitas, 1998)

This measure presents 12 peer-related vignettes depicting situations where there is a possibility of rejection. For each vignette, participants must first rate how anxious they would be in that situation, using a six point likert scale ranging from 1 (not nervous) to 6 (very nervous). The participants are then asked to specify how likely it is that the other person would respond with rejection or acceptance, choosing between three categories (i.e., yes, no or maybe). Research shows good internal consistency for this measure (Qualter et al., 2013). The Cronbach’s alpha in this study was (.94).

### Visual Analogue Scales (VASs)

A self-report questionnaire using VASs (i.e., 10cm long) was used to determine participants' state levels of anxiety (anchored by 'not at all' and 'extremely') and mood (anchored by 'extremely low' and 'extremely high').

#### 5.3.3.2. Sentence completion task (adapted from Cardi et al., 2015; Hayes, Hirsch, Krebs, & Matthews, 2010; Huppert et al., 2007).

This computer-based task asks participants to generate completions to ambiguous social scenarios. Over headphones, participants listen to 12-stem sentences (i.e., 2 practice trials and 10 test trials) that describe socially ambiguous scenarios that involve the risk of social rejection (e.g., "*Your teacher calls you into her office to tell you that you did something...*"). Participants write down onto paper as many short word completions to the scenarios as they can and are asked to indicate with an asterisk the completion that they think '**best**' completes the scenario. The scenarios were adapted from those used by Cardi et al. (2015) so that they were age appropriate (e.g., relating to school as opposed to work). Two raters (R.T. and J.L.) who were blind to the conditions of the sample, scored participants' 'best' completions on the sentence completion task as negative or benign. The inter-rater reliability was checked using the kappa statistic (.91), and a third party rater resolved any disagreements (V.C.).

#### 5.3.3.3. CBM-I training (modified from Cardi et al., 2015; Hirsch, Hayes, & Matthews, 2009).

This included a total of 100 trials: 90 interpretation modification trials and an additional 10 catch trials presented in a random order. Scenarios were presented to participants over headphones, and each described a situation that was ambiguous with the potential for an interpretation of social rejection, until the last word resolved the ambiguity in either a benign or negative manner. For example: "*You text your sister to arrange going shopping but she doesn't reply. You think she is (really busy/ ignoring you)*". At the conclusion of each scenario, a comprehension question is given with a yes/no option (e.g., "*Is your sister too busy to reply right now?*"), and the correct

answer confirms the outcome of the scenario. The aim of this question was to reinforce the valence of the modification trial, in either a benign or negative way. A computer-generated tone followed their response to give the participant feedback on whether the answer was correct or incorrect. Catch trials were also included to reveal whether participant's interpretational style was changing during the course of the training. These trials kept their ambiguity and were followed by a comprehension question (e.g., "*Are you concerned that your sister is ignoring you?*"). As the item was ambiguous, there were no correct or incorrect answers meaning no feedback was given.

The experimental condition involved entirely benign endings to the social scenarios, and the control condition included a 50:50 split of benign/ negative endings. The task was administered in blocks of 5 and each block contained 18 training scenarios and 2 catch trials, with a break in between each block if the participants required it. To increase the ecological validity of the training, ambiguous scenarios were developed by patients from the hospital (i.e., those not involved in the study) to increase their relevance to adolescents.

#### 5.3.3.4. Filler task: the speed of comprehension test (Baddeley, Emslie, & Nimmo-Smith, 1992).

Following the training, participants completed this as a filler task to lower the chance of group differences in mood influencing the Cyberball game. This follows the protocols of other CBM-I training studies (e.g., Hayes et al., 2010, Lothmann, Holmes, Chan, & Lau, 2011). The task consisted of 100 sentences, half of which are "true" and half of which are "false" (e.g., "Bears live in trees"), and participants indicate with a tick which are true. Instructions emphasised that speed was not important. Any sentences relating to food were removed to prevent a negative impact on mood.

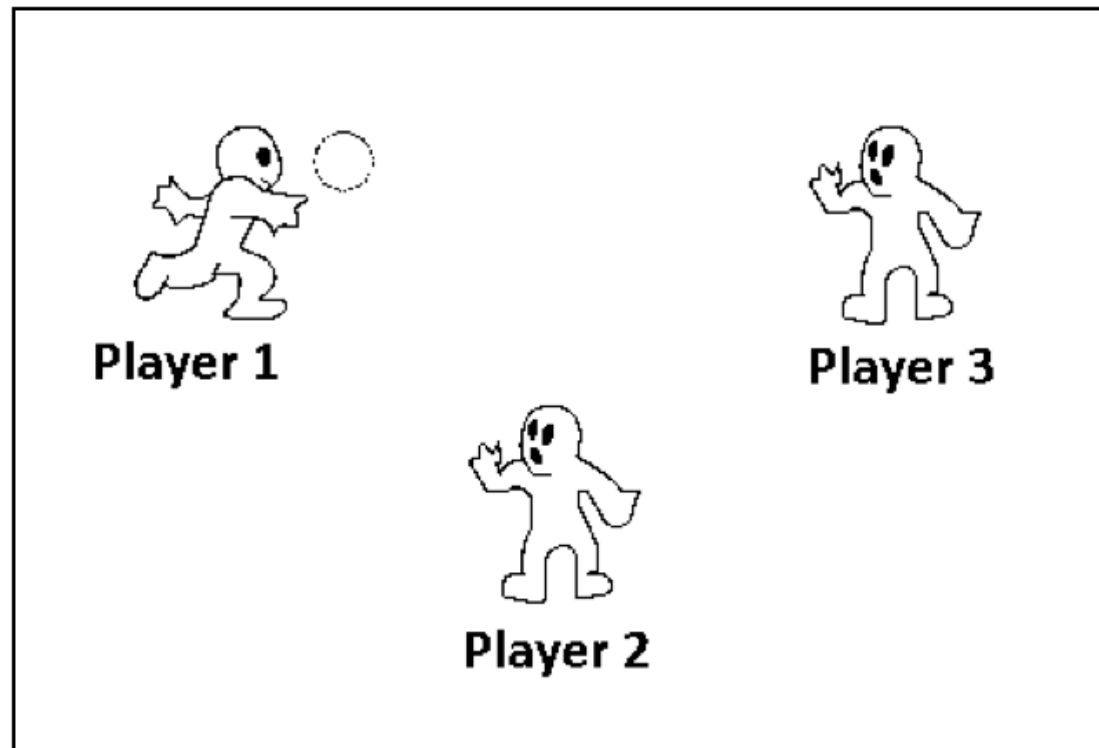
#### 5.3.3.5. Cyberball task (Williams, Cheung, & Choi, 2000).

This computer-based task (depicted in **figure 1.**) can create feelings of ostracism. It is a ball throwing game in which the participant receives the ball a

limited number of times. Participants were asked to mentally visualise that they were participating in the game. There were a total of 30 throws with participants being thrown the ball only 6 times, randomly during each session.

#### 5.3.3.6. Needs Threat Scale (Van Beest, & Williams, 2006).

This self-report questionnaire was used to measure participant's levels of self-esteem and feelings of meaningful existence after the Cyberball task, and is measured on a 7-point likert scale. Higher scores on these subscales were indicative of more positive levels of self-esteem and meaningful existence respectively. The questions used were piloted with a group of healthy adolescents to check that they were age appropriate. Other studies that use the Needs Threat Scale have also included the subscales for feelings of belonging and control however, these subscales were not assessed for in the present study given that the number of ball throws to the participant in the Cyberball task was set in both conditions at 6 times meaning that their level of belonging and control in the game was fixed (i.e., they were partially excluded in both conditions) and, therefore, not hypothesised to be susceptible to change in the present study. The Cronbach's alphas in this study were .85 for the self-esteem and .78 for the meaningful existence subscale.



**Figure 1.** This image shows the Cyberball task. Participants are informed to visualise the game and that they are player two.

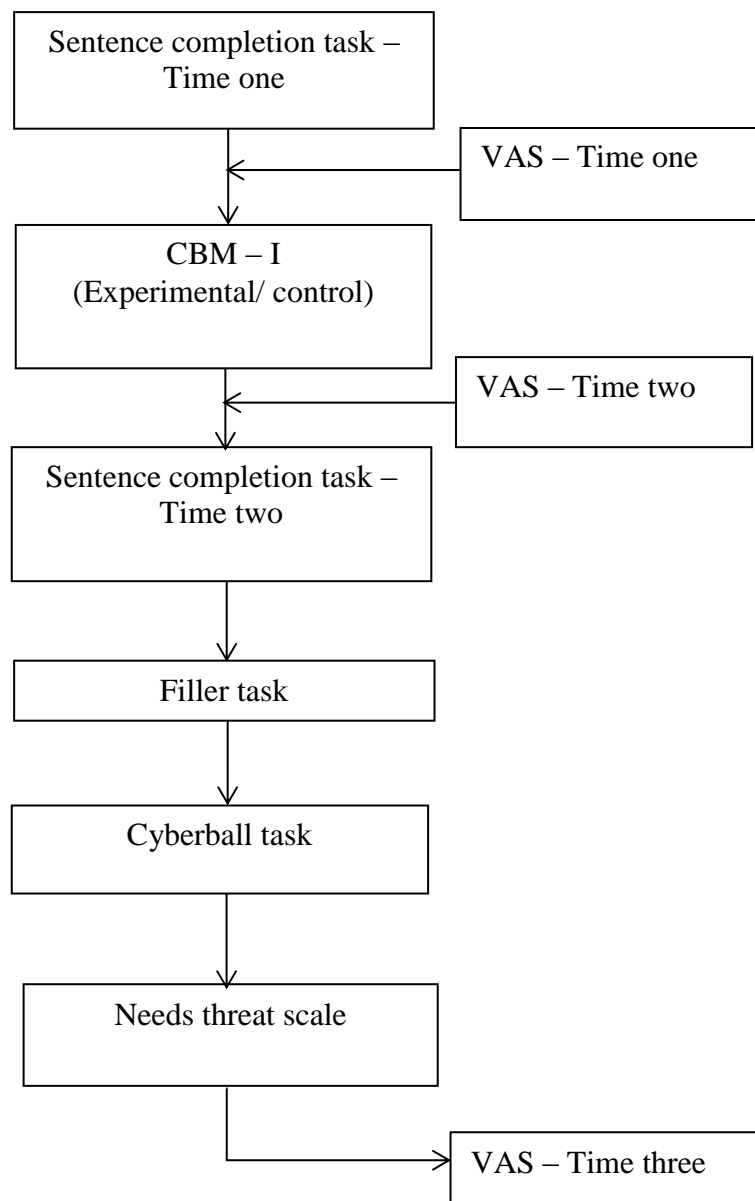


#### *5.3.4. Procedure*

Please see **figure 2.** for an outline of the procedure. Testing for the experiment took place at the hospital site and consent was gained from both the participants and their guardians. The procedure involved completing the sentence completion task, which was done on a laptop with headphones (using E-PRIME, version two; E-Prime, 2016). The CBM-I training was then administered on the same laptop with headphones, followed by the second sentence completion task. VASs were also completed before and after the CBM-I training. A filler task was then given, and the online Cyberball game was completed followed by the Needs Threat Scale. A week later participants completed the other training condition (either the experimental or control condition depending upon randomisation). Participants were fully debriefed following the study.

### Study outline

Repeated one week apart using a within-subjects design



**Figure 2.** This diagram shows the protocol for the study. This design was repeated over two sessions in total. Abbreviations: VAS = Visual Analogue Scale; CBM-I = Cognitive bias modification for interpretations.

### 5.3.5. Data Analysis

Clinical characteristics were examined using descriptive statistics (SPSS, version 22). To examine whether the young people had a negative interpretation bias for social stimuli at baseline, the frequency of negative and benign ‘best’ interpretations was compared on the first sentence completion task that they completed as part of the study using a Wilcoxon-signed ranks test. Spearman’s rank correlations were used to assess for associations between a negative interpretation bias and clinical characteristics.

Training fidelity was examined by assessing participant’s accuracy on the comprehension trials and catch trial responses during the CBM-I task. Participants ‘best completions’ on the sentence completion task were then compared pre and post the experimental or control condition to examine whether the CBM-I training modified participants interpretational styles (a near transfer outcome of the study). A  $p$  value of  $< .05$  was used as the threshold for statistical significance.

Participant’s responses on the VASs for anxiety and mood were analysed using separate mixed effects linear models using a 2x2 design (i.e., training condition x time point). This analysis was completed on Stata version 14<sup>®</sup> (StataCorp, 2015) and was bootstrapped at 1000 repetitions. Scores on the Needs Threat Scale were compared between the experimental and control condition with Wilcoxon-signed ranks tests. A  $p$  value of  $< .05$  was used as the threshold for statistical significance. These were considered far out come measures for the training. Effect sizes were calculated and interpreted using Cohen’s (1988) guidelines of  $.1 \Rightarrow$  small,  $.3 \Rightarrow$  medium and  $.5 \Rightarrow$  large.

## 5.4. Results

### 5.4.1. Clinical characteristics

**Table 1.** shows the sample characteristics. There were high rates of co-morbidity for anxiety and depression (67%), and the majority of the sample was on psychotropic medication (92%). There was a wide variation in both the length of admission and weight for height at the time of testing.

Clinical characteristics	Mean (SD)	Min - Max
Age	15.87	14-17
Weight for height	84.17 (11.85)	59.82-101.98
Length of admission (days)	116.75 (116.84)	7-447
Illness duration (years)	2.66 (1.81)	.0-6
EDEQ - Weight	4.18 (1.74)	1-6
EDEQ - Shape	4.76 (1.58)	.75-6
EDEQ - Restraint	3.43 (1.86)	0-6
EDEQ - Eating concern	3 (1.63)	.4-6
EDEQ - Total	3.75 (1.54)	.59-6
RCADS - Total anxiety	57.26 (22.59)	18-92
RCADS - Major depression	16.74 (6.48)	4-27
CRSQ	18.81 (7.78)	5.67-32.5

**Table 1.** This shows the sample demographics and clinical characteristics. Abbreviations: EDEQ = Eating Disorders Examination Questionnaire; RCADS = Revised Children's Anxiety and Depression Scale; CRSQ = Children's Rejection Sensitivity Questionnaire.

### 5.4.2. Interpretation bias at baseline

At baseline the young people made significantly more negative 'best' interpretations ( $Mdn = 7$ ,  $IQR = 6-9$ ) than benign ( $Mdn = 3$ ,  $IQR = 1-4$ ) on the sentence completion task ( $Z = 3.91$ ,  $p < .0001$ ,  $r = .56$ ). This negative interpretation bias for social stimuli significantly positively correlated with participants weight for height ( $p = .004$ ,  $r_s = .58$ ), EDEQ shape concerns ( $p = .036$ ,  $r_s = .47$ ), CRSQ total ( $p = .029$ ,  $r_s = .49$ ), RCADS total anxiety ( $p < .0001$ ,  $r_s = .69$ ) and RCADS major

depression ( $p = .039$ ,  $r_s = .42$ ). There were no significant correlations with age, illness duration or EDEQ total (all  $p > .05$ ).

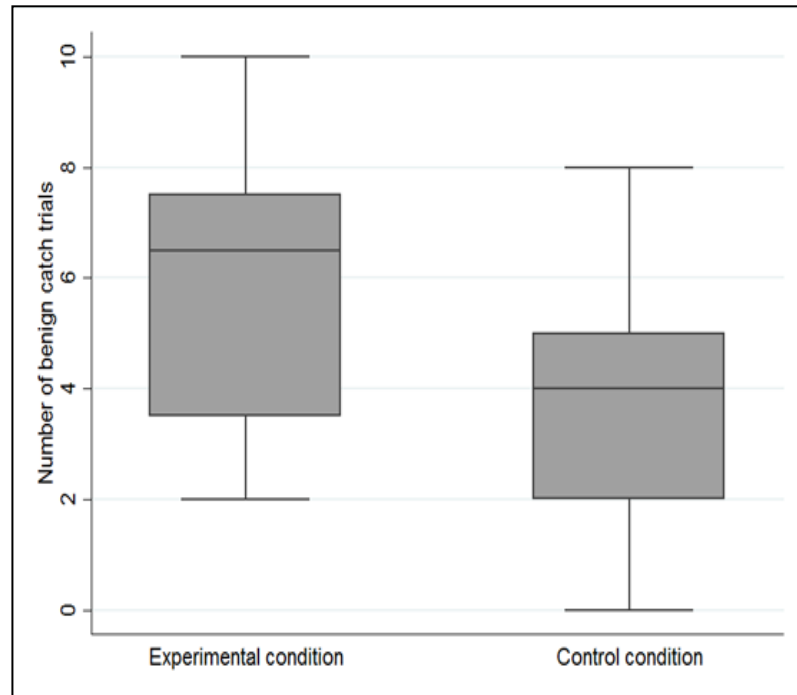
### **5.4.3. Training task data**

#### *5.4.3.1. Comprehension trial accuracy*

Participants accuracy levels on the comprehension trials did not significantly differ between the experimental ( $Mdn = 76$ ,  $IQR = 60-84.75$ ) and control conditions ( $Mdn = 77.5$ ,  $IQR = 61.75-83.5$ ;  $Z = -.7$ ,  $p = .484$ ,  $r = .1$ ). Please see **supplementary item 1**. for an analysis of the outcome data for only participants with accuracy levels over 80% on the comprehension trials.

#### *5.4.3.2. Responses to the catch trials*

The young people made significantly more benign responses to the catch trials in the experimental ( $Mdn = 6.5$ ,  $IQR = 3.25-7.75$ ) versus control condition ( $Mdn = 4$ ,  $IQR = 2-5$ ;  $Z = 3.395$ ,  $p = .001$ ,  $r = .49$ ). Please see **figure 3**.



**Figure 3.** This boxplot shows that the young people made significantly more benign responses to the catch trials in the experimental versus control conditions ( $p = .001$ ,  $r = .49$ ).

#### 5.4.4. Near transfer outcome measure

##### 5.4.4.1. Best' interpretations on the sentence completion task

Post experimental training participants made significantly fewer negative interpretations ( $Mdn = 6$ ,  $IQR = 4.25-8.75$ ) than pre ( $Mdn = 8$ ,  $IQR = 5.25-9$ ;  $Z = -2.92$ ,  $p = .003$ ,  $r = .42$ ). They also made significantly more benign interpretations post training ( $Mdn = 4$ ,  $IQR = 1.25-5.75$ ) than pre ( $Mdn = 2$ ,  $IQR = 1-3.75$ ;  $Z = -3.152$ ,  $p = .002$ ,  $r = .45$ ).

Post control training there were no significant differences for negative (Pre  $Mdn = 6$ ,  $IQR = 6-8$ ; Post  $Mdn = 6.5$ ,  $IQR = 4.25-9$ ;  $Z = -.406$ ,  $p = .685$ ,  $r = .06$ ) or benign interpretations compared to pre training (Pre  $Mdn = 4$ ,  $IQR = 2-4$ ; Post  $Mdn = 2.5$ ,  $IQR = 1-5$ ;  $Z = -.335$ ,  $p = .738$ ,  $r = .05$ ).

#### 5.4.4.2. Visual analogue scales

##### 5.4.4.2.1. Mood ratings

A 2x2 mixed effects linear model (i.e., training condition x time point) showed that there was no significant main effect of training condition ( $X^2(1) = 2.25, p = .133$ ), time point ( $X^2(2) = 2.27, p = .32$ ) or interaction between training condition and time point ( $X^2(2) = .84, p = .65$ ).

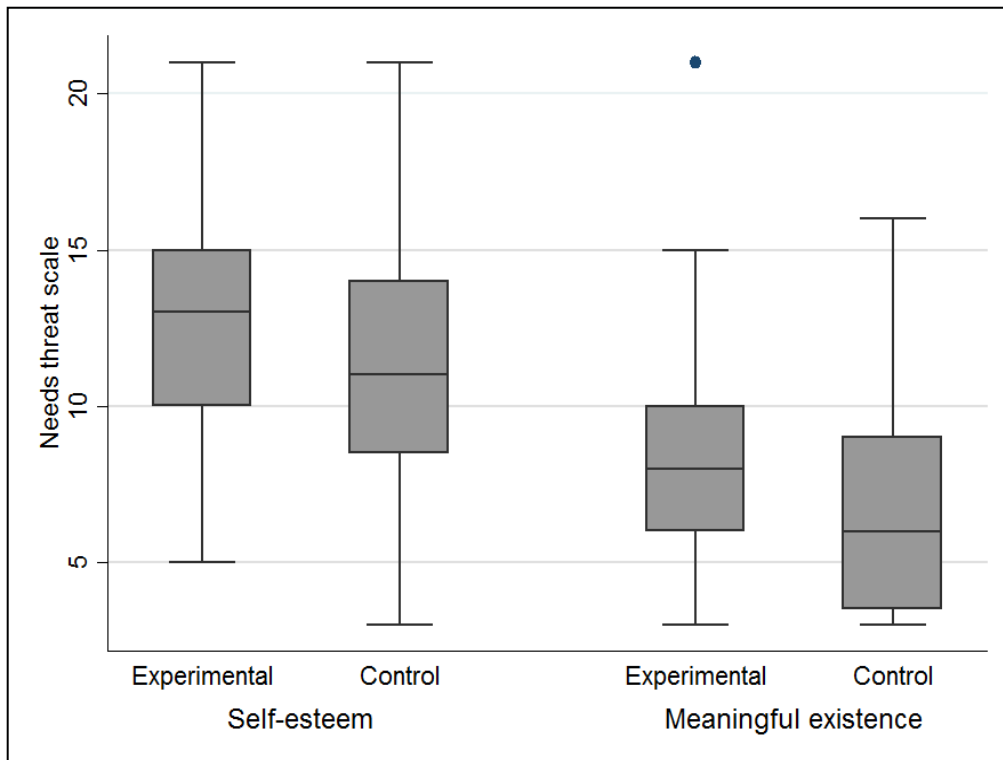
##### 5.4.4.2.2. Anxiety ratings

A 2x2 mixed effects linear model (i.e., training condition x time point) showed that there was a significant main effect of condition on participants anxiety ratings ( $X^2(1) = 5.41, p = .02$ ). Pairwise comparisons showed that anxiety ratings were significantly lower in the experimental ( $M = 5.7, SD = 2.79$ ) versus control training ( $M = 6.41, SD = 1.97; Z = -2.33, p = .02$ ). There was no significant main effect of time point ( $X^2(2) = 1.38, p = .502$ ) or interaction between training condition and time point ( $X^2(2) = .13, p = .94$ ).

#### **5.4.5. Far transfer outcome measure**

##### *5.4.5.1. Need threat scale (post Cyberball task)*

There was a trend for participants to have significantly higher levels of self-esteem after the Cyberball task in the experimental ( $Mdn = 13, IQR = 10-15$ ) versus control condition ( $Mdn = 11, IQR = 8.25-14.5; Z = -1.69, p = .091, r = .24$ ). There was no significant difference for participants' levels of meaningful existence after the Cyberball task in the experimental ( $Mdn = 8, IQR = 6-10$ ) versus control condition ( $Mdn = 6, IQR = 3.25-9; Z = -1.092, p = .275, r = .16$ ).



**Figure 4.** This boxplot shows that there was a trend for participants to have significantly higher (more positive) levels of self-esteem after the Cyberball task in the experimental versus control condition ( $p = .091$ ,  $r = .24$ ). There was no significant difference or trend for participants' levels of meaningful existence between conditions ( $p = .275$ ,  $r = .16$ ).

## 5.5. Discussion

This proof of concept study investigated whether one session of CBM-I training was able to modify a negative interpretation bias for social stimuli and rejection sensitivity for adolescents receiving inpatient care for AN. The first hypothesis was supported in that experimental CBM-I significantly reduced a negative interpretation bias for social stimuli. Concerning the second hypothesis, a non-significant trend was found, suggesting that both self-esteem (small to moderate effect) and meaningful existence (small effect) were higher following the experimental versus control condition.



At baseline the negative interpretation bias for social stimuli was greater in adolescents than other published reports in adults with AN (Cardi et al. 2017). This corroborates previous research, which suggests that adolescence is a time of heightened rejection sensitivity (Sebastian et al., 2010, 2011). As a negative interpretation bias for social stimuli positively correlated with participant's weight for height and levels of shape concern, it may be the case that as adolescents with AN gain weight, they become more concerned about the possibility of rejection by their peers due to changes in their appearance. Future endeavours could test this hypothesis.

The finding that CBM-I training can remediate a negative interpretation bias is consistent with previous single session studies in healthy (i.e., unselected) adolescents (e.g., Lothmann, Holmes, Chan, & Lau, 2011; Salemink & Wiers, 2011, 2012). The trend for higher self-esteem levels in response to the Cyberball task in the experimental condition suggests there is the potential for far transfer of the training. Given the illness severity of the participants included within this study, it could be the case that multiple training sessions are needed to produce a larger effect on far transfer outcomes.

A strength of this study is the adaptation of the CBM-I training materials specifically for adolescents with AN. The task included a selection of social scenarios that were created by adolescents with AN themselves. This follows the recommendation that CBM-I research should ensure that training materials are both relevant and realistic for the participant group (Hughes, Gordon, Chalder, Hirsch, & Moss-Morris, 2016). There are also potential limitations to the study. The relatively small sample size means that the study may have been underpowered to detect far transfer changes. Another consideration is that the Cyberball protocol differed to previous research. For example, in this study, participants were thrown the ball 6 times at random, whereas in other procedures participants are thrown the ball consistently at the beginning of the task and then are excluded throughout the task (e.g., Masten et al., 2011). This adaptation was made so that there was an element of ambiguity as to whether they might be included within the task.

## 5.6. Clinical implications

No participants dropped out of the study suggesting that the training was acceptable for adolescents with AN. Future research may examine whether techniques to increase engagement with the intervention, such as gamification, help to increase the effect of CBM-I. An exploratory analysis of the data of the participants ( $N = 12$ ) with accuracy over 80% on CBM-I trials showed a slightly larger effect for a reduction in negative interpretation bias ( $r = .52$ ) than found in the main analysis ( $r = .42$ ) (see **supplementary item 1**).

## 5.7. Conclusion

To date, this is the first study to use CBM-I training in adolescents with AN. This study found a single session of CBM-I training significantly reduced a negative interpretation bias for social stimuli and facilitated a more benign interpretational style in comparison to a control condition. There was also a trend for the adolescents to have greater resilience of self-esteem in response to a social rejection task. Future endeavours may pilot the use of multiple CBM-I training sessions for adolescents with AN, potentially as an online or mobile application.

## **5.8. Chapter summary**

At baseline adolescents with AN made significantly more negative, than benign, ‘best’ interpretations of ambiguous social scenarios that involve the hypothetical risk of rejection. This negative interpretation bias for social stimuli positively correlated with participant’s weight for height, shape concerns, major depression, anxiety, and rejection sensitivity. This is the first study to date to then use CBM-I training in adolescents with AN to help facilitate a more benign interpretational style. It found that that a single session of CBM-I training significantly reduced a negative interpretation bias for social stimuli, and facilitated a more benign interpretational style, relative to a control condition (a 50% dose of benign training). Furthermore, there was also a trend for greater levels of self-esteem in response to the Cyberball task in the experimental condition. The findings of this study give support to the hypothesis that a negative interpretation bias for social stimuli is associated with rejection sensitivity in adolescents with AN. It seems warranted for future research to test the use of multiple CBM-I training sessions using a randomised controlled design.

Chapters three, four, and five of this thesis have focused on the use of CBM-I for people with AN. The next part of this thesis, chapters six, seven, and eight, will now focus on the use of cognitive training approaches (in particular food-specific inhibitory control training) for people with BN and BED. This is in line with the need for more precise and targeted treatment approaches for these populations (e.g., Voon, 2015). Therefore, the next chapter of this thesis will review the key mechanisms that may underlie binge-type eating disorders with the goal of highlighting new treatment targets.

## Chapter six:

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### Review one

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# Emotional Eating, Binge Eating and Animal Models of Binge-Type Eating Disorders

Robert Turton<sup>1</sup> · Rayane Chami<sup>1</sup> · Janet Treasure<sup>1</sup>

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## Abstract

**Purpose of Review** The objective of this paper is to review the role that hedonic factors, emotions and self-regulation systems have over eating behaviours from animal models to humans.

**Recent Findings** Evidence has been found to suggest that for some high-risk individuals, obesity/binge eating may develop as an impulsive reaction to negative emotions that over time becomes a compulsive habit. Animal models highlight the neural mechanisms that might underlie this process and suggest similarities with substance use disorders.

**Summary** Emotional difficulties and neurobiological factors have a role in the aetiology of eating and weight disorders. Precise treatments targeted at these mechanisms may be of help for people who have difficulties with compulsive overeating.

**Keywords** Emotional eating · Neurobiology · Animal model · Bulimia nervosa · Binge eating disorder

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Robert Turton and Rayane Chami are joint first authors

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✉ Robert Turton  
robert.turton@kcl.ac.uk

Rayane Chami  
chami.rayanne@gmail.com

Janet Treasure  
janet.treasure@kcl.ac.uk

<sup>1</sup> Department of Psychological Medicine, Section of Eating Disorders, King's College London, Institute of Psychiatry, Psychology and Neuroscience, 103 Denmark Hill, London SE5 8AZ, UK

## Introduction

Gerald Russell first described bulimia nervosa (BN) in 1979 [1], and binge eating disorder (BED) has only been recently accepted as a diagnostic category in the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders [2]. BN and BED are characterised by a loss of control over eating and the rapid consumption of large amounts of food [2]. In BN, compensatory behaviours are used to prevent weight gain (e.g. self-induced vomiting/compulsive exercising). These disorders are often co-morbid with obesity [3] and share similar risk and maintaining factors. Anorexia nervosa (AN) is characterised by under-eating and weight loss, although a substantial proportion of people with AN also binge eat and/or use compensatory behaviours [2].

In primary care, an increasing number of people received a diagnosis for an eating disorder in the 1980s and in the early 1990s [4–6]. This trend has continued into the beginning of the millennium [7]. The incidence rates of obesity have also increased at the same time worldwide [8]. One explanation for these trends is an increased level of awareness of eating disorders amongst the general population and clinicians. Another possibility is that this pattern of changes is due to new factors within the environment that may be impacting on eating and weight control.

There have been rapid changes in the food environment over the last 60–70 years with food technology changing what and how we eat [9]. For instance, nutrients have been ultra-processed and or purified, and foods have been modified to make them more accessible, cheaper and palatable [10]. The impact of these environmental changes on eating behaviour might be modified by individual factors [11]. For example, genetic factors may modulate the vulnerability to develop abnormalities in eating behaviours [12•], whilst the hedonic value of food [13] and emotions [14•] are other key factors that

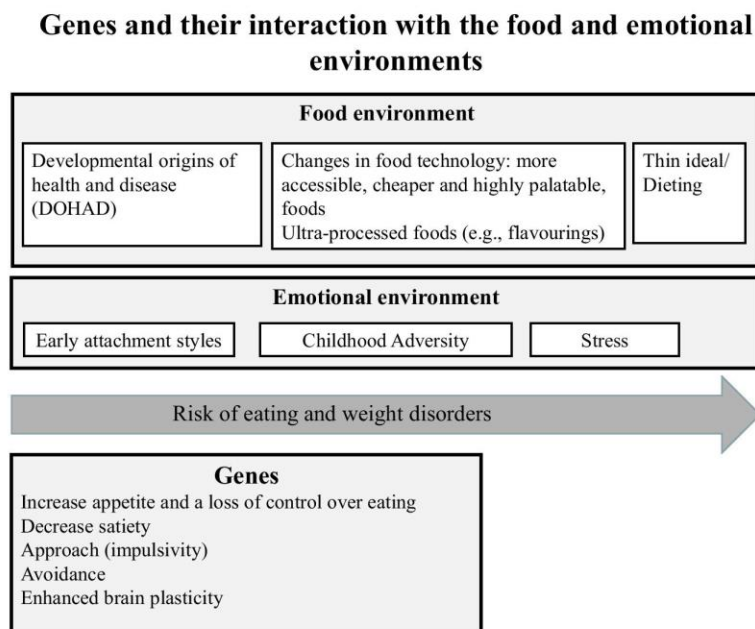
may influence eating behaviour. These factors may promote either approach or avoidance behaviours towards food due to the processes of reward and punishment (see [15, 16] for detailed reviews of these motivational systems). Moreover, they may override the homeostatic control of eating behaviour and over time lead to overeating.

This paper will summarise animal models of pathological eating behaviour to help delineate the various mechanisms that may increase the risk for disordered eating behaviour. It will then outline recent findings in humans and suggest potential treatment targets. Please see Fig. 1 for an overview of the key risk factors that will be covered within this review.

### Animal Models of Eating Behaviour—Possible Translational Insights

A variety of animal models have been developed in order to characterise the possible mechanisms involved in pathological eating behaviour and weight homeostasis in humans [17–20]. These models are based upon findings from lesion studies, pharmacological manipulations and by controlling the environmental conditions of rodents. Many of the models developed have included the factors that are thought to increase the risk of eating and weight disorders in humans. Therefore, they might help to understand the mechanisms that underpin abnormal eating behaviour.

**Fig. 1** Genes and their interactions with the food and emotional environments. This highlights the role that genetics and environmental factors (i.e. food and emotion related) have in the development of eating and weight disorders



### Homeostatic Mechanisms and Eating Behaviour

Innate homeostatic mechanisms control nutritional balance. The hypothalamus plays a key role in the homeostatic control of eating [21]. For example, lesion studies in rats have allowed the identification of the specific structures involved, such as the hypothalamic ventromedial, paraventricular and dorsomedial nuclei as satiety centres and the lateral hypothalamus as a hunger centre [22, 23].

Circuits including the nucleus accumbens, the amygdala, the lateral hypothalamus and the ventral tegmental area are involved in hedonic food consumption. For recent reviews regarding the role of these circuits in eating behaviour and reward, please see [24, 25]. Also, please refer to [26] for an outline of the role of endocrine factors (i.e. leptin, ghrelin and insulin) on eating behaviour beyond the scope of this review. However, the specific neurochemicals involved in hedonic eating are worth discussing.

### Dopamine

Research has shown that daily binge eating on a palatable sugar or fat diet is associated with increased dopamine release in the nucleus accumbens [27]. It is thought that the pleasure experienced from highly processed foods is positively correlated with the amount of dopamine released in the striatum. Over time, this leads to the downregulation of the expression D2R dopamine receptors in the striatum [28, 29]. This downregulation is associated with food consumption becoming



more compulsive in its nature [31, 32•] and is similar to the rewarded processes observed in response to drugs of abuse [30]. Dopamine's role in food reward and addiction-like eating will be discussed below.

## Opiates

Central opioid signalling pathways are also involved in food reward [33]. For instance, rats that overeat palatable food (i.e. glucose) show increased opioid receptor binding in the nucleus accumbens shell, the locus coeruleus, the cingulate cortex and the hippocampus [34, 35]. Furthermore, opioids are involved in the hedonic aspects of food consumption (e.g. pleasantness). Naloxone, an opioid antagonist, decreases the overall consumption of a sucrose diet [36]. Also, opioid antagonists decrease the intake of preferred foods to a higher degree than non-preferred foods [37], thus demonstrating opioid's role in reward experienced from hedonic food consumption.

## Oxytocin

The effects of the neuropeptide oxytocin on food consumption are complex, as it appears to be involved in not only the maintenance of homeostasis but also in the regulation of hedonic eating [38, 39]. Oxytocin is thought to suppress the activation of reward pathways [41]. During palatable food intake, the release of endogenous opioids acts to inhibit oxytocin neurons, contributing to inhibitory control over intake [42]. As such, research shows that the central administration of an oxytocin receptor agonist reduces the tendency to restrict palatable food intake in a novel/stressful eating environment [40]. Moreover, mice whose oxytocin gene expression was knocked out consumed significantly more sucrose solution compared to their wild-type cohorts, implying that oxytocin pathways play a role in hedonic eating by increasing inhibitory control over intake [42].

## Rodent Models of Non-Homeostatic 'Binge-Like' Eating

A variety of permutations of the environment have been found to induce rats to 'binge eat' (i.e. to overeat rather than to eat in accordance with homeostatic principles). Most of these involve limiting food intake, increasing food reward or associating food with punishment.

- Limited access models [43].

Intermittent, limited access to palatable food has been used to change eating behaviours and promote overconsumption.

Importantly, after a fasting period, increased food intake continues even after basic metabolic needs are met.

- A stress-induced hyperphagia model [44].

This model suggests that food restriction combined with stress (e.g. an electric foot shock) induces binge-like increases in energy intake greater than that caused by restriction alone.

- Sham feeding models [45].

This model involves using a gastric fistula to induce drainage of consumed food before it enters the intestine [20]. Under such states, rats show an increase in binge eating behaviour as compared to control rats [46]. This sham feeding is often used to reproduce the compensatory behaviour of vomiting, impaired satiety and overeating amongst individuals with BN [17].

## Food Palatability (Reward)

There has been a recent change in the food environment caused by technological modification of foods to increase their palatability. Several animal models include exposure to such palatable foods as a means of modulating the hedonic response to food. Some people and some rodents are more susceptible to change their eating behaviour in response to these foods than others [47, 48]. In support of this notion, it is possible to separate out binge eating prone (BEP) and binge eating resistant (BER) rats following exposure to palatable food [49]. BEP rats consistently consume more than twice the amount of palatable food compared to BER rats, although they show an appropriate homeostatic eating response when sated and when hungry [49]. The rats prone to overeat with palatable food over time become obese. These traits vary within wild-type rat strains, and there has been selective breeding to produce rats with sensitivity to dietary-induced obesity. Obesity-prone rats show greater changes in limbic and motivational circuits in response to palatable food [25, 48, 50•]. Moreover, these foods also produce a marked increase in AMPA glutamate receptor in the nucleus accumbens [25]. These findings suggest that there is an interaction between genotype and availability of highly palatable foods.

## Stress (Punishment)

Exposure to aversive environments has been used to change eating behaviour in rodents. Short-term stressors such as cold exposure, water exposure or social defeat can reduce feeding behaviour in animals [44, 51]. However, chronic stress can lead to overfeeding on palatable food [52]. Pijlman and

colleagues [53] examined the impact of emotional stress (i.e. rats watch another rat receiving foot shocks) on eating behaviour versus physical stress (i.e. repeated foot shocks) in rodents. They found that emotional stress was associated with a preference of saccharin and hyperactivity, whereas physical stress was associated with a preference for water and anhedonia. Therefore, emotional distress has been found to increase hedonically driven eating in rodents.

### **‘Addiction-Like’ Eating Behaviour: How Binge Eating in Animals Relates to Substance Use Disorders**

The change from impulsive responding and approach to the reward of highly palatable food into a more compulsive behaviour, which occurs even in the face to adverse consequences, is thought to be the mechanism that accounts for ‘food/eating addiction’. This is a similar process to what occurs with substances of abuse (e.g. alcohol, cocaine use).

Indeed, there are similarities in the brain circuits and neurochemistry found with addiction to both substances and food [54]. For example, diets consisting of intermittent access to high-sucrose drinks are associated with a change in the balance of dopamine and acetylcholine in the brain. When these animals are given naloxone, extracellular dopamine and increased acetylcholine in the nucleus accumbens decreases [55]. Moreover, animals given naloxone show somatic signs of withdrawal, demonstrating symptoms such as anxiety, teeth chattering, forepaw tremor and aggression [55–58]. This suggests that opiate mechanisms are involved in this model of food/eating addiction [56]. Furthermore, the finding that rats are motivated to seek out highly palatable foods regardless of shocks to their feet is comparable to compulsive eating in humans, in which the behaviour persists despite negative consequences [59]. However, it is important to note that the magnitude of the effect is comparatively smaller for food than substances of abuse.

### **In Summary**

- Changes in the food environment (palatable food, restriction and intermittent exposure) and also stress can lead to changes in eating behaviour in rodents. The context is important.
- The duration of stress (i.e. chronic or acute) and the kind of stressor (i.e. emotional or physical) differentially impact on eating behaviour.
- ‘Addiction-like eating behaviour’ occurs in animals when they continue to seek food even though they receive negative consequences (e.g. punishment with electric foot shocks).

- Changes in brain chemistry (e.g. dopamine and endogenous opiates) underpin eating behaviour in these animal models. For example, opiate-like withdrawal symptoms develop after the administration of naloxone and opiate antagonists.

In the following section, we will examine parallels between these processes and human eating behaviour.

## **Humans: Risk and Maintenance Factors**

### **The Barker Hypothesis**

In 1990, David Barker hypothesised that pre-natal and early post-natal experiences, such as under-nutrition during gestation or a low birth weight, predict the later onset of illness (see [60] for a review). This is now known as Developmental Origins of Health and Disease (DOHAD) and has a well-documented impact on body weight and metabolism [61]. Longitudinal studies of people exposed during early gestation (i.e. during the first trimester) to severe starvation in the Dutch famine of 1944–1945 have found higher levels of obesity amongst other adverse health markers in later life [62, 63]. A systematic review has found evidence that pre-natal exposure to diabetes, famine and cigarette smoking was linked to childhood overweight and obesity [64]. It has been suggested that these pre-natal factors alter the development of the endocrine system [64]. A range of obstetric complications have also been positively associated with the development of AN (e.g. maternal diabetes) and BN (e.g. low birth weight) [65].

### **What Is the Evidence for a Genetic Vulnerability for Problems in Eating Behaviour in Humans?**

Some people appear to have a genetic susceptibility to anomalies in appetitive traits and behaviours [66–68]. Many genetic loci associated with obesity, such as variants in FTO, MC4R and BDNF genes, are expressed primarily within the hypothalamus and are thought to impact appetitive behaviours. For example, children with the AA genotype of the FTO (rs9939609) were reported by their parents to have inefficient satiety responsiveness [69]. Moreover, children with AA alleles and those with a single A allele for FTO have been found to consume significantly more than participants who were homozygous for the T allele on a test meal [70•].

Furthermore, individuals with a higher polygenic risk score (based upon 32 genetic loci) for obesity have been reported to have increased emotional and uncontrolled eating [71•]. Specifically, variants of FTO, ZC3H4, MTCH2 and TNNI3K were positively associated with emotional eating. A recent study [72] also examined whether the polygenic risk



score (based upon 32 genetic loci) was associated with eating disorders. The FTO gene in particular was linked with the development of binge eating in adolescence. Another group of researchers [73] found that 34.7% of children homogenous/heterogeneous for the A allele self-reported a loss of control over eating versus 18.2% of the children homogenous for the T allele of FTO and those participants either homogenous/heterogeneous for the A allele ate highly palatable, energy-dense foods more frequently although in the context of a test meal, no differences in total energy intake occurred.

Genetic factors are also associated with disorders of under-eating (for a recent review, see [12•]). To date, genome-wide association studies of AN have not been sufficiently powered to indicate significant genetic loci [74, 75]. Nonetheless, they have suggested that studies with greater sample sizes could highlight genetic loci associated with AN and whether there is a specific polygenic risk profile for either of the AN subtypes (i.e. restricting or binge/purge) [e.g. 74]. This emerging research is helping to clarify the role of genetic factors in eating behaviours.

### Early Adversity and Eating Behaviour

The early emotional environment also impacts on eating behaviour. Early attachment experiences increase the risk of eating disorders [76•, 77] and obesity [78]. Furthermore, adolescents [79, 80] and adults [81, 82] with AN have insecure patterns of attachment. A recent meta-analysis concluded that this effect was large (Cohen's  $d = 1.3$ ) [76•].

Early adverse experiences impact on eating behaviour and weight control. A variety of abusive experiences increase the risk of BN and binge eating behaviour [83]. These types of experiences (i.e. psychological abuse, sexual abuse, physical abuse and neglect) are also more common in obese individuals [84, 85].

### Hedonic Eating

Obese people appear to be oversensitive to approach food and experience higher levels of food craving [86–88]. This is associated with increased activation of the nucleus accumbens [89]. Moreover, longitudinal studies have found that atypical activation of nucleus accumbens in response to food cues is associated with weight gain [90, 91].

People with BN have been found to have an increased nucleus accumbens volume relative to healthy controls [92]. Furthermore, people with BN and BED are reported to have greater medial orbitofrontal cortex (OFC) volumes in comparison to people without eating disorders [92] and show

increased activation of the OFC in response to food cues [93]. The medial OFC has been implicated in both reward processing [94] and impulsivity [95].

### What Role Does Emotional Eating Have in the Development of Changes in Eating Behaviour and/or Weight Homeostasis?

The propensity to eat in response to positive [96•] and negative emotions [97, 98] is called '*emotional eating*' [99, 100]. Laboratory-based research has shown that emotional eating is predictive of increased food intake in young people [101]. However, there is uncertainty about the association between emotional eating and weight gain in children and adolescents. Cross-sectional research has shown greater levels of emotional eating in young people who are overweight relative to those within the healthy weight range [102, 103]. Other studies have not supported those findings (e.g. in girls [104]). A potential explanation is that, during childhood and adolescence, the relationship between food intake and BMI is non-linear, as weight gain may be more greatly influenced by other genetic and behavioural factors at this stage of development [104]. Indeed, eating in the absence of hunger at age 7 has been found to predict binge eating problems in adolescents (i.e. at age 15), with a higher BMI, dietary restraint, body dissatisfaction and negative affect elevating the risk [105]. Another recent prospective study showed that after a 1-year interval, emotional eating alone was not related to weight gain in adolescents; however, in conjunction with loss of control over eating, there was weight gain at the 1-year follow-up [106•].

In adulthood, there is a clearer association between emotional eating and obesity [107, 108]. Cross-sectional questionnaire-based research has shown that overweight/obese women report greater levels of emotional eating than participants within the healthy weight range [109, 110]. A 2-year prospective study has shown that emotional eating moderated a relationship between the overconsumption of food and weight gain [111].

With regards to BED, Masheb and Grilo found that emotional eating, particularly anxiety, is positively associated with eating psychopathology [112]. More recently, researchers have found that anger, feeling hurt by others, feeling disappointed, sadness and feeling guilty were associated to binge eating, suggesting that emotional eating may be related to a wide range of negative emotions and problematic interpersonal relationships [113]. This is in line with research that has suggested that people with eating disorders are often highly sensitive to social threat and rejection [114, 115].

**Table 1** Emotion-based models of binge eating psychopathology

Model	Description
Emotion regulation model [120, 121]	The central tenet of this model is that binge eating is a maladaptive coping strategy for negative emotions. It suggests that binge eating reduces negative affect after eating excessive amounts of food. This strategy is negatively reinforced due to the temporary alleviation of distress that eating causes.
Escape theory [122]	The main proposition of this theory is that binge eating is a means of escaping or detaching oneself from negative aversive states. This is because during binge eating episodes, cognitive narrowing occurs whereby attention becomes solely focused towards the immediate environment such as food and disinhibited eating follows. This model suggests that binge eating is negatively reinforced as negative affect decreases during the episode of overeating.
The dual-pathway model of BN [123, 124]	The dual-pathway model suggests that there are two pathways that can lead to the development of BN symptoms. The first pathway involves dieting, and the second involves eating to reduce negative affect. For example, internalisation of the thin ideal may promote feelings of body dissatisfaction and negative affect. As a result, people may resort to extreme diets in order to try and achieve the thin ideal and improve their mood. However, dieting is often unsuccessful leading to further feelings of body dissatisfaction and increased negative affect. These pathways can lead to the development of BN symptoms.
Three-phase model of socioemotional functioning in eating disorders [125]	This model suggests that there are three phases of socioemotional functioning in eating disorders. The first phase involves predisposing factors for the illness such as adverse perinatal events, early attachment and temperament styles (e.g. shyness). The second phase describes maintaining factors of the illness such as difficulties in emotion regulation and a heightened sensitivity to rejection. The third stage is the impact of the eating disorder on close others. For instance, it may lead to an increase in carer anxiety or avoidance behaviours. This, in turn, may lead to deterioration in the patient's socioemotional functioning.

Several theoretical models have been proposed to outline the role of emotions in the development and maintenance of binge eating in humans

Ecological momentary assessment (EMA) techniques have been used to investigate the effect of emotions on binge eating episodes for people with BN and BED [116–118]. A meta-analysis of the EMA literature found that people report increased levels of negative affect prior to binge eating (medium effect size = 0.63) and that this negative affect increases even further following the episode (medium effect size = 0.5). For people with BN, negative affect was found to decrease following episodes of purging (medium effect size = -0.46) [119]. However, a limitation of EMA techniques is that this approach can only suggest an association, not causation, between negative affect and binge eating.

To help address this limitation, Cardi et al. did a meta-analysis of experimental studies that induce a negative or positive mood within the laboratory and assess subsequent eating behaviour on a test meal in comparison to a neutral condition. This review found that negative mood induction leads to increased food consumption, with greater effects in restrained eaters (very large effect size = 1.5) and people with BED (large effect size = 0.74) [14•]. It also showed that positive mood induction leads to increased food consumption in HCs (small effect size = 0.3). For people with BN, a limited number

of studies suggested that positive mood induction could help to reduce food consumption. Please see Table 1 for an overview of several emotion-based theoretical models for the development and maintenance of the binge eating episodes.

### Control Over Eating Behaviour: Impulsive and Compulsive Traits

Emotions are linked to drives to approach or withdraw from food; impulsive or compulsive patterns of behaviour can develop in response to these tendencies [126•, 127]. Smith and Robbins propose that overeating behaviours in obesity and BED may begin as an impulsive behaviour driven by reward [127]. However, with repetition, excessive habit formation may cause the behaviour to become triggered by cues such as negative affect rather than by reward. This occurs due to stimulus response learning and may be similar to the processes involved in addiction in substance use disorder (for a recent comprehensive review, see [128]).

Pearson et al. have suggested that impulsive and compulsive traits might also underlie the psychopathology of BN



**Table 2** Translating animal models of overeating to humans: targets for new treatment approaches

Animal models of overeating	Translation to humans	Examples of targeted treatment approaches
Food rations are reduced.	Dieting and prolonged fasting	Implementation intentions (if-then planning approaches to help counter dieting) (e.g. [141])
They are given highly palatable, high sugar/fat food at irregular and unpredictable times.	Cravings lead to an impulsive episode of eating snack food, which is ubiquitous in Western societies.	Food-specific inhibition training (e.g. [142]) Attention bias modification (e.g. [143]) Approach-avoidance training (e.g. [144])
Stress induces overeating.	The trigger to diet is often a stressful event or difficulty. This leads to episodes of overeating.	Voccasts: the use of calming music, imagery and guided relaxation scripts to help induce a positive mood for people with eating disorders (e.g. [145])
Downregulation of reward-based neural pathways.	Binge eating becomes compulsive in its nature.	Oxytocin administration (e.g. [146]).
Their stomach contents are drained after eating.	Vomiting and satiety disturbance in BN.	Implementation intentions (if-then planning approaches to help counter purging)

In this table, we link what is known to predispose overeating in animals to what happens in humans. This has implications for the use of targeted treatment approaches

[129•]. They also proposed that emotions have a core role in the development and maintenance of symptoms. This model hypothesises that there are two pathways towards the development of binge eating. The first *state-based* pathway suggests that when people experience negative emotions, there is a reduction in self-control. As a result, people may binge eat as they are unable to maintain the effortful demands of dietary restraint. The second pathway suggests that *trait-based* factors have a role in the development of BN. Specifically, the model suggests that the personality trait of negative urgency may make individuals vulnerable to over consume food, which is easily accessible during times of distress, with the expectation that it will provide relief. At the beginning of the illness, this behaviour is rewarding as it provides a distraction from negative emotions, whilst purging helps to lower feelings of distress that follow the binge. However, as the illness develops, these symptoms become compulsive as they continue despite the serious risks to health that are associated with them (e.g. cardiac problems). Furthermore, the function of the binge eating episodes shifts from being a distraction from negative emotions to a way of avoiding them completely.

A key mechanism that might underpin both impulsivity and compulsivity in obesity, BED and BN is impaired inhibitory control [126•]. This may be defined as the inability to stop an action [130]. Indeed, a systemic review of the literature [131] has shown that people with BED and BN have difficulties in inhibitory control (small effects  $-0.26$  for BN and  $-0.16$  for BED), with enhanced difficulties for illness-specific stimuli in BN (i.e.

large effect sizes for food/eating =  $-0.67$  and body-related stimuli =  $0.61$ ). In keeping with this notion, research has found that impaired inhibitory control is positively associated with a poorer treatment outcome for overweight children [132, 133]. It is thought that this inefficient self-regulatory system might be due to abnormal brain activation in the fronto-striatal networks [134–137]. Consequently, difficulties in inhibitory control may be one mechanism that helps to explain why people with obesity and binge eating develop eating behaviours that can become highly persistent and difficult to change. This predisposition to compulsively overeat may underpin obesity and eating disorders and is a possible target for treatment [138].

## In Summary

- Food intake in humans is regulated by homeostatic/hedonic factors and memory (a full review of their role was beyond the remit of this article; nevertheless, please see [139, 140] for comprehensive reviews).
- People with obesity and binge eating crave highly palatable, energy-dense foods and find them highly rewarding.
- Evidence has been found to suggest that there is a genetic susceptibility for appetitive traits, obesity, binge eating and emotional eating.
- Emotional eating appears to have a role in the development and maintenance of obesity and binge eating.

- Difficulties in inhibiting approach or avoidance tendencies in response to emotions can lead to abnormal eating behaviours.
- Difficulties in inhibitory control can produce compulsive responding and habit formation.

## Clinical Implications

This review has potential implications for the treatment of obesity/binge-type eating disorders. Recently, there has been an increasing focus on the use of novel treatment enhancers for eating and weight disorders. In line with this, please see Table 2 for an overview of how animal models of overeating translate to humans and examples of possible targeted treatment approaches.

## Conclusion

This paper has covered recent studies relating to risk and maintenance factors for obesity and binge-type eating disorders. It suggests that there may be a genetic risk for overeating and binge eating behaviours, and these may develop as an impulsive coping strategy for negative emotions. This symptom may become compulsive in nature due to the process of excessive habit formation. Animal models highlight neurochemical changes that underlie inhibitory and reward pathways, which contribute to the maintenance of compulsive overeating. Additionally, through inducing forced abstinence, intermittent access, restriction and environmental stress, they offer valuable insight that is comparable to eating disorder populations. Moreover, they allow researchers to draw comparisons to substance use disorders, by inducing withdrawal and tolerance. Consequently, it may be of benefit to draw upon the use of novel targeted treatment approaches to further improve treatment outcomes for people with these conditions.

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## Compliance with Ethical Standards

**Conflict of Interest** Robert Turton, Rayane Chami and Janet Treasure declare they have no conflict of interest.

**Human and Animal Rights and Informed Consent** This article does not contain any studies with human or animal subjects performed by any of the authors.

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## **6.1. Chapter summary**

This review considered how hedonic factors, emotions, and self-regulation systems control eating behaviour in animals and humans with a particular focus on the factors that might cause and maintain binge-type eating disorders. It highlights that binge-eating might begin as an impulsive action that becomes compulsive as the illness progresses. Animal models have increased understanding of the neural processes involved and indicate similarities with substance use disorders. As this review has mapped the mechanisms underlying binge-eating psychopathology, the next step is to consider possible techniques to target them. The next chapter of this thesis will systematically review novel approaches that aim to promote healthier eating habits that could potentially be of benefit for people with eating disorders.

## Chapter seven:

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### Review two

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## Review

## Novel methods to help develop healthier eating habits for eating and weight disorders: A systematic review and meta-analysis

Robert Turton<sup>\*</sup>, Kiki Bruidegom, Valentina Cardi, Colette R. Hirsch<sup>1</sup>, Janet Treasure<sup>1</sup>

Department of Psychological Medicine, King's College London, Institute of Psychiatry, Psychology and Neuroscience, 103 Denmark Hill, London SE58AF, United Kingdom

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## ABSTRACT

This paper systematically reviews novel interventions developed and tested in healthy controls that may be able to change the over or under controlled eating behaviours in eating and weight disorders. Electronic databases were searched for interventions targeting habits related to eating behaviours (implementation intentions; food-specific inhibition training and attention bias modification). These were assessed in accordance with the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines. In healthy controls the implementation intention approach produces a small increase in healthy food intake and reduction in unhealthy food intake post-intervention. The size of these effects decreases over time and no change in weight was found. Unhealthy food intake was moderately reduced by food-specific inhibition training and attention bias modification post-intervention. This work may have important implications for the treatment of populations with eating and weight disorders. However, these findings are preliminary as there is a moderate to high level of heterogeneity in implementation intention studies and to date there are few food-specific inhibition training and attention bias modification studies.

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<sup>\*</sup> Corresponding author. Tel.: +44 02078485980.

E-mail addresses: [robert.turton@kcl.ac.uk](mailto:robert.turton@kcl.ac.uk) (R. Turton), [kiki.bruidegom@kcl.ac.uk](mailto:kiki.bruidegom@kcl.ac.uk) (K. Bruidegom), [valentina.cardi@kcl.ac.uk](mailto:valentina.cardi@kcl.ac.uk) (V. Cardi), [colette.hirsch@kcl.ac.uk](mailto:colette.hirsch@kcl.ac.uk) (C.R. Hirsch), [janet.treasure@kcl.ac.uk](mailto:janet.treasure@kcl.ac.uk) (J. Treasure).

<sup>1</sup> Joint last authors.

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## 1. Introduction

The transdiagnostic term eating disorders covers syndromes with eating behaviours ranging from under to over controlled eating (Fairburn et al., 2003). The most common form of psychological treatment across the spectrum of illnesses is Cognitive Behavioural Therapy (CBT) and the main elements used to change eating behaviours are monitoring (eating and compensatory behaviour diaries) and setting goals for food plans, which include regularly spaced meals. However, even in the optimal conditions of a clinical trial these approaches are only moderately effective and 40–60% of patients remain symptomatic at the end of treatment. In order to help explain this resistance of eating disorder symptoms to change, explanatory models have begun to focus on the role of habit formation in the development and maintenance of psychopathology (O'Hara et al., 2015; Steinglass and Walsh, 2006; Treasure et al., 2014; Walsh, 2013).

A staging model of eating disorders (Treasure et al., 2014) has recently highlighted how eating disorder psychopathology may follow a projected trajectory across the lifespan with symptoms becoming more embedded and complex over time. In the severe and enduring stage of illness it is hypothesised that eating disorder habits are deeply entrenched resulting in neuroprogressive changes and decreased treatment responsiveness. Excessive habit formation is proposed to be a mechanism that maintains the compulsive nature of dietary restriction in anorexia nervosa (AN) (Walsh, 2013) and the impulsive/compulsive nature of overeating behaviours in obesity, binge eating disorder (BED) and bulimia nervosa (BN) (Berner and Marsh, 2014; Smith and Robbins, 2013). Parallels have been drawn between the role of habit formation in eating and weight disorders and other impulsive/compulsive disorders (Robbins et al., 2012). Based upon this emerging area of research, the purpose of this review will be to examine the effectiveness of novel approaches for developing healthier eating habits that may be valuable in the treatment of eating and weight disorders.

### 1.1. Excessive habit formation and compulsivity in AN: Transdiagnostic comparisons

Gardner (2015) defines habit as, “a process by which a stimulus automatically generates an impulse towards action, based on learned stimulus-response associations” (p. 280). Walsh (2013) proposed that excessive habit formation might be a maintenance mechanism in AN. This model states that dietary restriction is initially goal-directed with a variety of possible aims such as losing

weight or managing emotions. Individuals develop fixed dietary patterns and exclude a wide variety of foods from their diet. They may also engage in over-exercising behaviours as a means of weight-loss. During this stage weight loss may be positively reinforced, with individuals often reporting that they received compliments or concern from their peers and family and an increased sense of self-esteem/mastery. However, when maintained over time, dietary restriction may develop into a deeply entrenched habit primarily driven by automatic (stimulus-response rather than goal-driven) processes that are initiated by cues that are both internal (e.g., negative affect, physiological effects) and external (e.g., interpersonal difficulties) to the individual. Over time excessive habit formation may underpin the shift from weight-loss being initially rewarding to becoming compulsive in its nature.

Compulsivity involves the repetitive performance of actions that often result in negative consequences. These actions are typically the result of rigid-rules and are performed as a means of avoiding the perceived negative consequences of not carrying out the action (e.g., strict dietary rules may be followed in AN due to a fear of becoming overweight if they are broken) (Dalley et al., 2011; Fineberg et al., 2014; Fontenelle et al., 2011). Robbins et al. (2012) have advocated for a transdiagnostic approach to compulsivity based upon commonalities in cognitive, behavioural and neural processes across disorders and co-morbidities. This approach suggests that research should focus on transdiagnostic constructs to help aid treatment development rather than on traditional diagnostic criteria.

Comparisons have been drawn between compulsivity in AN and other compulsive disorders such as: substance use disorder, obsessive-compulsive disorder (OCD), and obsessive-compulsive personality disorder (Godier and Park, 2014; Park et al., 2014). For example, the persistent nature of weight-loss in AN has been likened to compulsive drug-taking in substance use disorder as these behaviours both continue despite their detriment to health (Godier and Park, 2015). Theories of habit formation are well established within the fields of substance use disorder and OCD, suggesting that the excessive formation of stimulus-response behaviours leads to compulsive drug-taking behaviours in substance use disorder (Everitt and Robbins, 2015; Pierce and Vanderschuren, 2010) and stereotyped/ritualised behaviours in OCD (Gillan et al., 2014; Gillan and Robbins, 2014). It is possible that excessive habit formation might be a mechanism that underpins compulsivity across disorders (Robbins et al., 2012). Consequently, there is a need for interventions that could help to break the stimulus-response habits that maintain compulsive behaviours.



### 1.2. How overeating transitions from an action to a compulsion: The role of impulsivity and habit formation

Impulsivity is multifaceted and predisposes individuals to act without forethought to potential negative consequences (Dalley et al., 2011; Fineberg et al., 2014). The construct is considered to comprise of numerous sub-domains including deficits in inhibiting responses, attention and decision-making (Reynolds et al., 2008). Impulsivity manifests in a range of illnesses such as: substance use disorder (Grant and Chamberlain, 2014), impulse-control disorders (Grant and Potenza, 2006), behavioural addictions (Blanco et al., 2009; Grant et al., 2010; Robbins and Clark, 2015) and Attention-Deficit Hyperactivity Disorder (ADHD) (Lopez et al., 2015). As a result, a transdiagnostic approach to impulsivity has been argued for alongside compulsivity (Robbins et al., 2012). It is thought that both constructs may co-exist within and across a range of disorders and that the balance of the two constructs might contribute to their specific psychopathology (Grant and Kim, 2014; Grant and Potenza, 2006).

The action-to-habit theory of substance use disorder suggests that drug use may initially begin as an impulsive action that becomes compulsive through excessive habit formation (Everitt and Robbins, 2005; Everitt and Robbins, 2015). This action-to-habit theory may also help to explain how compulsive overeating develops (Robbins et al., 2012; Smith and Robbins, 2013). For example, within western societies whereby palatable foods are widely available, impulsivity might predispose individuals towards overeating. Episodes of overeating might become linked with cues (e.g., advertisements/negative affective states) that trigger food cravings and further overconsumption (e.g., binge-eating). This may lead overeating to transition from being an impulsive action to compulsion. Evidence has been found to support the role of habit formation and impulsivity/compulsivity in obesity, BED and BN.

### 1.3. Impulsivity and compulsivity in obesity

It is possible that impulsivity underlies obesity as individuals may find it harder to resist unhealthy palatable foods (Nederkoorn et al., 2006). Nederkoorn et al. (2006) found that treatment-seeking obese children had less inhibitory control and were more sensitive to rewards than age matched healthy controls. Notably, poorer inhibitory control was found to be associated with less successful weight-loss during treatment (Nederkoorn et al., 2006, 2007). Similar findings of increased impulsivity and deficits in inhibitory control have also been reported in obese adolescents (Batterink et al., 2010) and young adults (Chamberlain et al., 2015; Jasinska et al., 2012).

Excessive habit formation may lead to the maintenance of overeating behaviours. Hortsman et al. (2015) recently found through a selective satiation task that a higher Body Mass Index (BMI) in adult males is linked with lower levels of behavioural sensitivity to changes in the motivational value of food. Habitual responding to food cues could be a mechanism leading to behaviours such as late meal cessation and eating in the absence of hunger (Hortsman et al., 2015). Thus, food cues might prompt obese individuals to overeat paralleling substance use disorder whereby drug related cues can induce compulsive drug-taking (Everitt and Robbins, 2015).

### 1.4. BED: The impulsive-compulsive nature of binge eating episodes

Binge eating is defined by episodes of overeating objectively large amounts of food accompanied by a subjective sense of loss of control. BED involves recurrent binge eating episodes that are associated with feelings of distress and guilt (American

Psychiatric Association, 2013). Obesity and BED are strongly connected with obese BED displaying high levels of impulsivity (Schag et al., 2013a,b) and compulsivity (Davis, 2013). Nazar et al. (2014) reported an association between BED and ADHD in a cross-sectional study of treatment-seeking obese women. Inattention symptoms and impulsivity traits were found to be strong predictors of binge eating severity. It is thought that food cues might highly engage the attentional focus of BED patients and decrease awareness on other cognitive processes, thus leaving them vulnerable to impulsive triggers of binge-eating (Nazar et al., 2014; Schag et al., 2013b).

Impulsive binge eating episodes might become compulsive due to excessive habit formation. Voon et al. (2015) used a decision making task to demonstrate that obese individuals with BED show a greater tendency to favour habit-based rather than goal-based learning approaches relative to obese non-BED. Neuroimaging data showed lower orbitofrontal cortex (OFC) and caudate nucleus grey matter volume in obese BED in comparison to obese non-BED. Hence, a bias towards habit-formation and neural deficits might underlie the compulsive nature of obese BED. This is similar to substance use disorder; with research finding that lower grey matter volume in the OFC is associated with a longer duration of illness and greater levels of compulsivity (Ersche et al., 2011).

### 1.5. The impulsive-compulsive nature of binge-purge behaviours in BN

BN is characterised by binge eating episodes and compensatory behaviours to prevent weight-gain (purging, laxative abuse, over-exercise and dietary restriction) (American Psychiatric Association, 2013). Pearson et al. (2015) have outlined a risk to maintenance model of BN suggesting that binge eating and purging episodes might begin as emotion driven impulsive actions that can become maintained as maladaptive emotion regulation strategies. For example, binge-eating episodes might initially be experienced as rewarding as they help to distract from the experience of negative emotions. After episodes of binge eating, purging might reduce feelings of guilt and discomfort. Over time, these behaviours develop into a means of avoiding anticipated painful emotions altogether rather than distracting from them. This is thought to parallel substance use disorder whereby drug taking may also be a method of avoiding distressing emotions (Baker et al., 2004). Therefore, binge-purge behaviours in BN might transition from being impulsive to compulsive behaviours that serve an avoidant function. In support of this, Engel et al. (2005) have found that higher levels of self-reported impulsivity and compulsivity are associated with greater levels of eating disorder psychopathology, depression and drug/alcohol addictions in community and treatment seeking females with BN.

Taken together, findings from across, obesity, BED and BN seem to support the notion that impulsivity and excessive habit formation are mechanisms underlying the compulsive nature of their psychopathology (Robbins et al., 2012).

### 1.6. Promoting healthier habit formation in dietary change

Based upon the role of excessive habit formation in eating and weight disorders interventions are needed to focus on creating new healthier habits alongside the disruption of the stimulus-response linkage that underpins maladaptive habits (Lally and Gardner, 2011; Wood and R  nger, 2015). Various novel interventions have recently been developed which interrupt this process by planning (e.g., implementation intentions) or acting through more automatic processes such as changing the attentional processes (e.g., attention bias modification training) or impulsive action tendencies (e.g., food-specific inhibition training) which determine eating behaviour (Quinn et al., 2010; Rothman et al., 2009; Wood and Neal,



2007). These approaches have been drawn from other fields such as substance use disorder (e.g., Cox et al., 2014; Wiers et al., 2013), and may be helpful as novel treatment enhancers for eating and weight disorders (Treasure et al., 2015).

### 1.7. Novel approaches for developing healthier eating habits and breaking maladaptive habits

#### 1.7.1. Implementation intentions

An approach to optimise planning and goal setting for behaviour change is implementation intentions (Gollwitzer, 1999). The aim of this approach is to strengthen deliberate processes of behaviour (van Koningsbruggen et al., 2014) by building counter habits. It involves the creation of action plans that state when, where and which behaviours should be performed in order to achieve a desired goal (Gollwitzer, 1999). For example, 'if I realise that I am calorie counting, then I will distract myself,' or 'if I need to buy a snack from a vending machine, I plan to get a whole-grain fruit bar'. These interventions are part of the motivational phase of behaviour change and are based upon the framework of the Theory of Planned Behaviour (TPB) (Ajzen, 1985). They can be used to either help develop a new healthier response to a situation or to increase self-control over maladaptive habits (Lally and Gardner, 2011).

Adriaanse et al. (2011b) performed a systematic review and meta-analysis of the literature relating to implementation intentions finding that they appear to be a helpful approach for increasing healthy food consumption ( $d=0.51$ ) and less so for reducing the consumption of highly palatable foods ( $d=0.29$ ). However, this study did not examine the long-term effectiveness of these changes or the impact of this approach on weight change. Furthermore, more studies in this area have recently been conducted meaning that it may be considered necessary to systematically review the effectiveness of this approach further.

#### 1.7.2. Food-specific inhibition training

Food-specific inhibition training is an approach that involves increasing inhibitory control specifically towards highly palatable foods (Veling et al., 2011a). It involves the use of computerised tasks such as the go/no go task and stop-signal task as a means of inhibiting automatic impulses towards highly palatable foods (Houben, 2011; Veling et al., 2011a). Go/no go training is based upon a choice reaction time paradigm whereby subjects are instructed to respond quickly and accurately to the presentation of a stimulus in the middle of a computer screen. This stimulus is presented alongside either a go or no/go cue such as the letters "P" or "Q" and only appears on screen for a brief period of time. Participants are instructed pre-task to respond to the presentation of a go cue (e.g., by pressing a computer key such as the space bar) and to withhold their response when the stimulus is presented alongside a no-go cue. Outcomes recorded for the go/no go task include reaction times to the stimuli and the accuracy of responses. When participants do not successfully withhold their response for the no-go cue it is indicative of a greater level of impulsivity (Band and van Boxtel, 1999). Through this approach pictures of highly palatable food stimuli can be consistently paired with no-go cues with the goal of increasing self-control towards these items of food.

Regarding the stop-signal paradigm, a similar procedure is followed to go/no go training with participants receiving instructions to respond rapidly to the onscreen presentation of stimuli whilst withholding their response when a stop-signal appears onscreen (e.g., a border around the target stimuli becoming bold). However, the procedure of stop-signal training differs from go/no go training in several ways: (1) participants must respond quickly to the presentation of both neutral and target stimuli onscreen; (2) participants are instructed to inhibit their response for only a

proportion of the target stimuli; and (3) there is a variable delay between the presentation of the food stimulus onscreen and the presentation of the stop-signal (Verbruggen and Logan, 2008). The stop-signal paradigm can be used as an assessment of the capability to suppress an already initiated motor response with longer reaction times to the stop-signal suggestive of a higher level of impulsivity and poor inhibitory control (Logan et al., 1997). This approach may also be used to increase inhibitory control towards highly palatable foods and may be of value in the treatment of disorders of overeating such as obesity, BED and BN (Juarascio et al., 2015).

#### 1.7.3. Attention bias modification

Research has suggested that biases in attention might underlie either under or over eating. For instance, patients with AN have been found to have biases in attention away from highly palatable foods (Veenstra and de Jong, 2012). In populations that overeat attentional biases towards highly palatable foods have been reported (Kemps et al., 2014a; Nijs et al., 2010; Nijs and Franken, 2012; Werthmann et al., 2015). The goal of attention bias modification is to remediate these cognitive biases in attention and to decrease the saliency of the environmental cues that may trigger eating habits.

The attention bias modification approach is computerised and is based upon a modified version of the dot-probe task and can be used to train early orientation styles in attention either towards or away from food or emotional stimuli (MacLeod et al., 1986). To do this, two stimuli appear onscreen either side of a fixation point; one food related, the other neutral. Following this a probe appears (e.g., the letter "E" or "I") which subjects must respond to quickly by pressing a computer key. To train attention towards food the probe consistently appears in the position vacated by the food stimuli or the neutral stimuli to train avoidance. Attention bias modification training may have potential as a widely disseminable treatment enhancer for eating disorders (Renwick et al., 2013) in either helping to develop healthier food intake or diminishing unhealthy food consumption.

The aim of the present systematic review and meta-analysis of the literature is to examine and compare the effectiveness of methods that have been found to change eating behaviours (i.e., implementation intentions, food-specific inhibition training and attention bias modification training). This is with the overall aim of translating possible new methods into clinical practice.

## 2. Method

### 2.1. Literature search

The electronic databases Embase, Medline, PsycINFO using Ovid and Science Citation Index Expanded (1900–present) and Scopus were searched for relevant articles written in English in peer reviewed journals during available years of publication to October 2014 following the PRISMA guidelines (Moher et al., 2009). The keywords used as search terms can be found in Table 1.

### 2.2. Inclusion/exclusion criteria

To be included in the systematic review and meta-analysis, studies were required to meet the following criteria: (1) measured the effectiveness of at least one session of a training intervention (i.e., implementation intention/action planning, food-specific inhibition training or attention bias modification); (2) eating behaviour and/or weight change as the primary outcome; and (3) random allocation of participants to the experimental or control condition.

**Table 1**

Search terms used for the different training approaches.

Construct (type of training)	Search terms
Implementation Intentions or action planning	(Implementation intention OR action planning) AND (food OR diet* OR eat* OR weight)
Food-specific inhibition training	(food OR diet* OR eat* OR weight) AND (inhibition OR impuls* OR self-control) AND (stop signal OR no-go)
Attention bias modification	Attention* bias AND (modification OR *training) AND (food OR diet* OR eat* OR weight)

\* Indicates truncation.

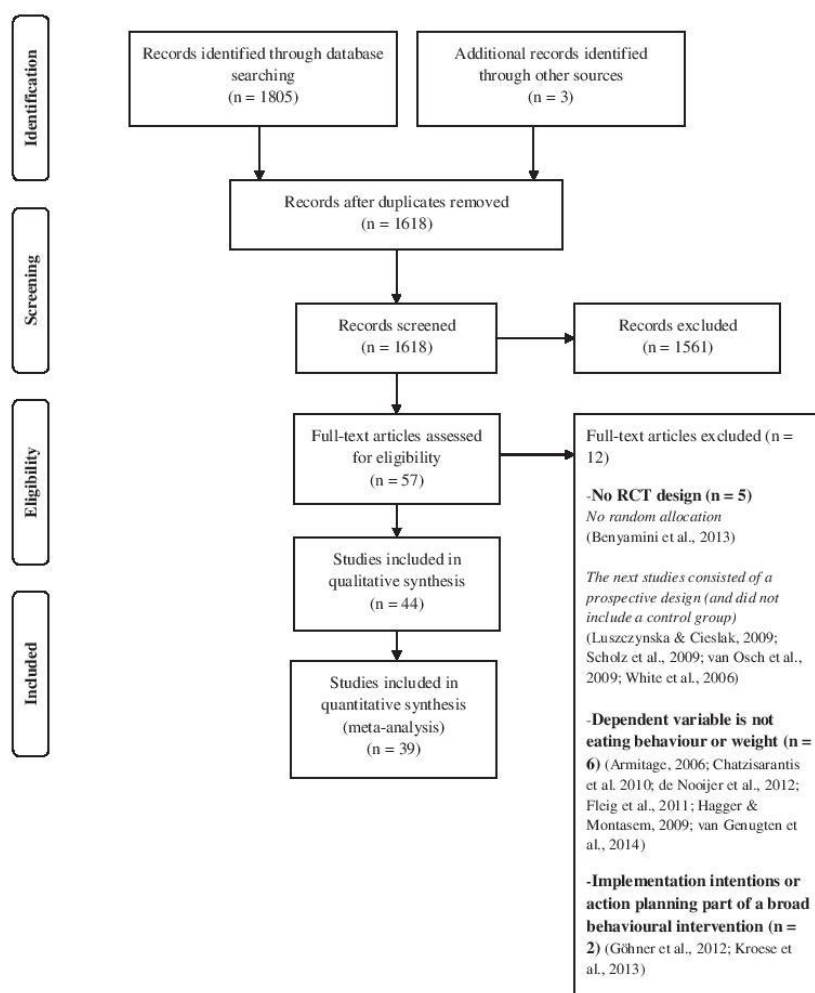
### 2.3. Study selection

One author (K.B.) performed the literature searches for the different training approaches and screened studies based on the content of their abstracts. Full text articles were assessed by two independent reviewers after which final screening and assessment for eligibility was agreed by two authors (K.B. and R.T.) Moreover, both authors (K.B. and R.T.) manually searched for studies by screening the reference lists of retrieved manuscripts and inspecting bibliographies from relevant labs in the field of these training approaches. If available, relevant articles at the submission stage

or in preparation by the authors of these labs were screened as well. The process of inclusion and exclusion of studies is shown in the PRISMA diagrams of study selection for all three training approaches separately (Figs. 1–3). A third reviewer was included in this process if there was uncertainty.

### 2.4. Data collection

In order to prepare data for meta-analyses means (M), standard deviations (SD) and sample sizes (n) for both intervention

**Fig. 1.** Flow Diagram on the search and selection of studies on implementation intentions.



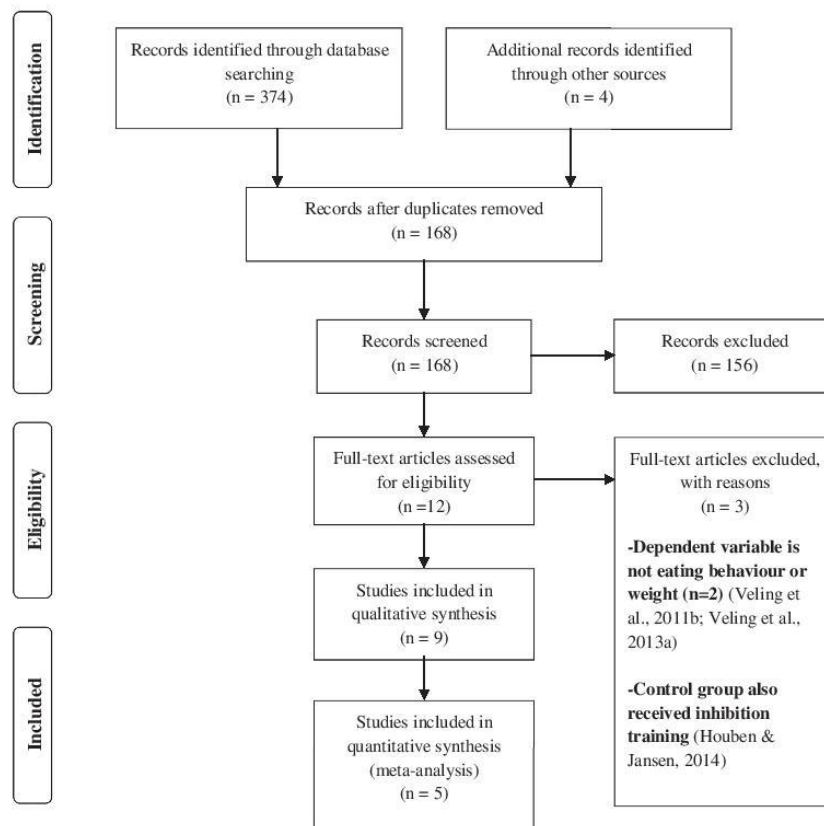


Fig. 2. Flow Diagram on the search and selection of studies on food-specific inhibition training.

and control (or comparison) groups were extracted from the articles. In studies where the Standard Error (SE) was reported, the SD was calculated from the SE using the following formula  $\bar{s} = s/\sqrt{n}$ . When data could not be retrieved from the articles, corresponding authors were contacted by email. Articles were excluded from meta-analysis when authors did not provide the particular data following two email requests.

## 2.5. Statistical analyses

Analyses were performed using Stata 11.0 (Stata Corporation, College Station, TX, USA) using the metan command (Bradburn et al., 1998), metanbias and metatrim (Steichen, 1998). The mean difference between intervention and control or comparison group for each training approach is measured by the Cohen's  $d$  effect size, the difference between two raw means divided by the pooled standard deviation. Cohen's effect sizes were interpreted as negligible ( $\geq -0.15$  and  $<0.15$ ), small ( $\geq 0.15$  and  $<0.40$ ), medium ( $\geq 0.40$  and  $<0.75$ ), large ( $\geq 0.75$  and  $<1.10$ ), very large ( $\geq 1.10$  and  $<1.45$ ) and huge ( $\geq 1.45$ ). Regarding the evaluation of the effect of different training approaches multiple meta-analyses were performed and

presented in Forest Plots. In regard to training approaches that aim to increase healthy eating behaviours a positive Cohens'  $d$  effect size favours the training approach; whilst a negative Cohen's  $d$  effect size favours the effect of training over control conditions in decreasing unhealthy food intake or reducing food intake. Random effects multivariate meta-analyses were performed to account for possible heterogeneity in the data and for both within and between study variance (Chen et al., 2012).

In order to assess the consistency of the results found and for any evidence of heterogeneity amongst the data the  $I^2$  percentage was calculated for each finding (Higgins et al., 2003).  $I^2$  scores range from 0 to 100% and describe the total variation across the studies included in the meta-analysis and indicate whether the findings may be due to sampling error or heterogeneity. Values of 25, 50 and 75% are interpreted as suggesting low, moderate and high levels of heterogeneity respectively. Publication bias was examined through the Egger's test (Egger et al., 1997), Begg's adjusted rank test (Begg and Mazumdar, 1994) and the trim and fill method (Duval and Tweedie, 2000). If these tests suggested that there was evidence for publication bias, funnel plots were completed to assess for publication bias in greater detail.



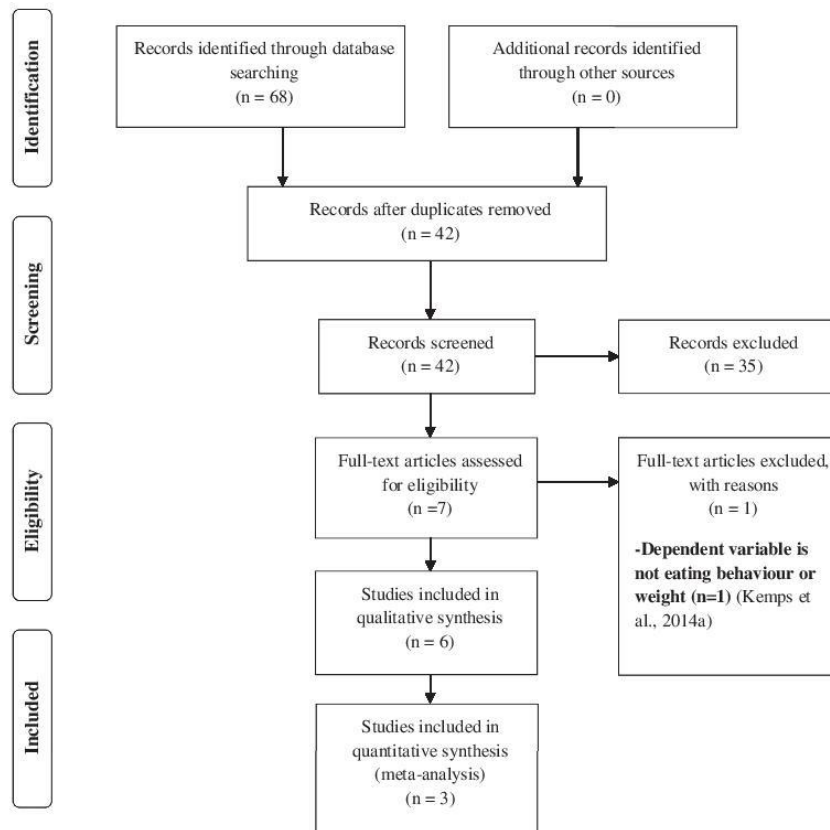


Fig. 3. Flow Diagram on the search and selection of studies on attention bias modification.

### 3. Results

#### 3.1. The effect of implementation intentions

##### 3.1.1. Overview of included studies

In total 44 studies were included examining the effect of implementation intentions on food intake and weight change. Studies were divided into different groups examining the effect of implementation intentions on: (1) increasing healthy food intake (see Table 2) and; (2) reducing unhealthy food intake (see Table 3). In the present meta-analysis a third group was identified examining the effect of implementation intentions on: (3) weight change (see Table 4). Results are discussed in these groups separately.

##### 3.1.2. Implementation intentions aimed at increasing healthy food intake

Five studies (de Nooijer et al., 2006; de Vries et al., 2008; Luszczynska et al., 2007c; Stadler et al., 2010; Verplanken and Faes, 1999) were excluded from the analysis because standard deviations and/or means were not reported. One more study was excluded from the meta-analysis since the effect size was more than three times higher above the average effect size and therefore considered as an outlier (Zhang and Cooke, 2012). Consequently, in total twenty-three studies were included in the forest plot (please refer to Fig. 4).

Participants in the implementation intention group increased their healthy food intake with a small effect size of 0.26 (95% CI: 0.16 to 0.37) compared to the control groups. There was evidence for publication bias (Begg's test  $p=0.012$ ; Egger's test  $p=0.011$ ). The trim and fill method estimated that nine studies were missing from the analysis resulting in an adjusted negligible effect size of 0.12 (95% CI: 0.01 to 0.24) after correcting for publication bias. For example, the funnel plots (Fig. 5) suggested that small studies with null effects are missing. Furthermore, because heterogeneity was found to be high ( $I^2=69.9\%$ ), a meta-regression was performed in which the variables, intervention type, time after intervention and outcome measures were entered. This simple model did not explain the heterogeneity.

Nine studies had outcome measures recorded after a follow-up period (please refer to Fig. 6). People in the implementation intention group were slightly more successful in increasing healthy food intake with a small effect size of 0.23 (95% CI: 0.08 to 0.38) relative to the control groups. We found no evidence for publication according to Begg's test ( $p=0.451$ ), however Egger's test did ( $p=0.006$ ). The trim and fill method estimated that six studies were missing from the analysis; the adjusted effect size is negligible 0.05 (95% CI:  $-0.1$  to 0.19) after correcting for publication bias. The funnel plots (Fig. 7) suggest that there is a lack of small sample size studies contradicting the effect of implementation intentions and a lack of larger sample sizes examining advocating the effect of implementation intentions on increasing healthy eating behaviour at follow-up.

**Table 2**

A summary of the included papers for Implementation intentions on increasing healthy eating behaviours.

	Training condition	Control condition	Session(s)	Time between plan and outcome	Behavioural outcome	Participants (at baseline)	Effect size (Cohen's <i>d</i> )
Adriaanse et al. (2009) Study 1	Implementation intentions with a motivational cue	Control	1	Directly after manipulation (for 7 consecutive days)	Food diary for 7 consecutive days; mean number of healthy snacks a day	108 female students	0.84
Adriaanse et al. (2009) Study 2	Implementation Intention with a personal motivational cue	Control	1	Directly after manipulation (for 7 consecutive days)	Food diary for 7 consecutive days; mean number of healthy snacks a day	72 female students	0.65
Adriaanse et al. (2010) Study 1	Implementation intention with mental contrasting	Control	1	Directly after manipulation (for 7 consecutive days)	Food diary for 7 consecutive days; portions of fruit in the past week	51 female students	0.13
Armitage (2007)	Implementation intentions	Control	1	2 weeks	Fruit intake over the last two weeks (sum) Number of days in the last two weeks where participants ate an extra piece of fruit	120 students	0.61 0.47
Armitage (2014)	Self-incentivising implementation intention	Control	1	1 month	Fruit intake using the fruit section of Bogers Frequency Measure	238 adolescents consuming fewer than 3 portions of fruits a day	−0.08
Chapman and Armitage (2010)	Implementation Intention plus an implementation intention at 3 months	Control	2	2 × 3 months	Single open-ended item: Fruit and vegetable intake per day over the last week FFQ: average fruit and vegetable consumption over the past year	650 undergraduate students	3 months: 0.24 6 months: 0.37 3 months: 0.10 6 months: 0.09
Chapman and Armitage (2012)	Implementation Intentions for fruit and vegetables separately	Control	1	2 months	Single open-ended item: Average portions of fruit a day over the past week Single open-ended item: Average portion of vegetables a day over the past week	580 students	0.16 0.25
Chapman et al. (2009)	Implementation intention	Control	1	1 week	Single open-ended item: Average fruit and vegetable intake a day over the past week	557 undergraduate students	0.13
*de Nooijer et al. (2006)	Implementation Intentions	Control	1	1 week	FFQ; Mean daily fruit consumption in grams	535 participants	NR
*de Vries et al. (2008)	Tailored health information letter plus Implementation Intentions	Tailored health information letter only	3 × 1 (letters; only action planning in last letter)	9 months	FFQ: Vegetable and fruit consumption; number of days in the past week (frequency) and average amount a day	2827 participants recruited through Dutch National Telephone Survey	−0.17 (fruit) −0.05 (vegetable) (derived from the paper)
Epton et al. (2014)	Online intervention based on Implementation intentions, a self-affirmation task and theory of planned behaviour messages	Control	Provided in app (participants could sign up for email reminders; read the interventions numerous times)	1 month 6 months After starting University (still enrolled in intervention)	Fruit and vegetable intake (portions per day) was measured with items based on the Health Survey for England (HSE)	1445 students (recruited 2 weeks prior to start of University year)	0.13 −0.02
Gratton et al. (2007)	Implementation Intentions	Control (implementation intention on homework)	1	1 week	7 day food diary Mean amount of fruit and vegetable portions in a week	198 children (secondary school)	0.71

Table 2 (Continued)

	Training condition	Control condition	Session(s)	Time between plan and outcome	Behavioural outcome	Participants (at baseline)	Effect size (Cohen's <i>d</i> )
Guillaumie et al. (2012)	Implementation intention plus self-efficacy	Control	4 × 2 h group meetings	At the end of the 1 month intervention 3 months	Self-report 6-item questionnaire on fruit and vegetable intake over the past week; average per day	163 participants	0.61 0.59
Guillaumie et al. (2013)	Implementation intention plus self-efficacy	Control	4 × 2 h group meetings	6 months 12 months	Self-report 6-item questionnaire on fruit and vegetable intake over the past week; average per day	291 participants	0.39 0.28
Harris et al. (2014)	Self-affirmed implementation intentions	Control (non affirmed; non implementation intentions)	1	1 week 3 months	Three measures assessing fruit and vegetable consumption (single open-ended item consumption on a typical day; Cambridge FFQ and consumption in a typical week on 7 points Likert Scale; results were standardized)	332 participants (students and staff at University)	0.79 0.69
Jackson et al. (2005)	Implementation Intention plus a Theory of Planned Behaviour Questionnaire	Control	1	7 days 28 days 90 days	Food diary of the previous 24 h; daily fruit and vegetable consumption (portions)	120 cardiac patients	−0.11 0.21 0.06
Karimi-Shahanjari et al. (2013)	Implementation intentions plus Theory of Planned Behaviour	Control	3 × 90 min	10 days 3 months	FFQ (Iranian version) assessing healthy snacks (26 options) over the past week	739 adolescent girls	−0.33 −0.01
Kellar and Abraham (2005)	Implementation intentions plus self-efficacy	Control	1	1 week	Single open-ended item: The number of days over the past week in which participants ate the required daily intake of fruit and vegetables	218 undergraduate psychology students	0.34
Knäuper et al. (2011a)	Implementation intentions plus mental imagery	Control	1	1 week	Single open-ended item: Number of fruit portions a day (average over the past week)	247 first year undergraduate students	0.30
Kothe et al. (2011)	Implementation intentions plus self-efficacy (called perceived behavioural control (PBC) in this paper)	Control	1	4 weeks	Single open-ended item: Number of days eaten breakfast over the past week	378 undergraduate students	−0.19
Kreausukon et al. (2012)	Intervention using self-efficacy tasks, Implementation intentions and coping planning <sup>7</sup>	Control (nutrition education only)	Several sessions lasting one weekend	1 week 6 weeks	Average serving of vegetables and fruit a day over the past week	114 undergraduate students	0.53 0.49
Lange et al. (2013)	Implementation Intentions plus Self efficacy, action control and coping planning	Control (received nutrition quiz)	1 (45 min)	1 week	Average fruit intake a day over the past week	791 participants	0.21
Luszczynska and Haynes (2009)	Implementation intentions	Control	3 (directly after measurement, after 6 and 9 weeks)	4 months after the first implementation intention session	Two-item questionnaire on 5 point Likert Scale; Mean number of fruit and vegetable intake a day	182 students (46% BMI > 25)	0.26
Luszczynska et al. (2007c)	Implementation Intentions plus Self-efficacy	Control	2 × 1 (received email for both self-efficacy and action plans based on scores at T0)	6 months	Single item question on 7-Points Likert Scale; fruit and vegetable consumption over the past two weeks; average a day scored	285 participants (adults) 26% were overweight/obese	NR
Reuter et al. (2008) Study 2	Implementation Intentions	Control	1	4 weeks	Average portion of fruit and vegetables a day over a period of four weeks	115 participants (only <i>n</i> = 19 in control group)	0.52



Table 2 (Continued)

	Training condition	Control condition	Session(s)	Time between plan and outcome	Behavioural outcome	Participants (at baseline)	Effect size (Cohen's <i>d</i> )
*Stadler et al. (2010)	Implementation Intentions with mental contrasting <sup>2</sup>	Control	1	1 week 1 month 2 months 4 months 24 months	Food diary assessing fruit and vegetable intake for 7 consecutive days; Daily servings of fruits and vegetables were summed up per week.	255 women	NR
Tam et al. (2010)	Promotion focused implementation intention	Control	1	Directly after manipulation for 2 consecutive days	A self-reported online food diary of healthy snacks over a 2-day period (one each day)	559 undergraduate students	0.13
*Verplanken and Faes (1999)	Implementation intentions	Control	1	Directly after intervention (for five consecutive days)	Food diary for five consecutive days rated by blinded dieticians on a 2 point Likert Scale (bad, reasonable, good) on 6 aspects of food intake; resulting in a Mean healthiness rating	102 undergraduate students	0.47 (derived from paper)
Wiedemann et al. (2012)	Implementation intentions (formulating 1, 2, 3, 4 or 5 plans)	Control	1	1 week	Single open-ended item: fruit and vegetable intake eaten on a typical day over the past week	478 participants	0.48 (5 plans)
Zandstra et al. (2010)	Implementation intentions	Control	1	(2 weeks) (3 weeks)	4-week diary assessing the amount of meal replacement food usages; average amount of MR per week	57 overweight consumers using website on meal replacement foods	0.31 0.04
*Zhang and Cooke (2012) (a)	Implementation Intentions plus Self Efficacy (through the use of protection motivation messages)	Control	2 × 1 (first session focused on motivation; second on II)	4 weeks (2 weeks after II)	Adapted form of the FFQ; measuring fruit and vegetable intake	84 students	1.42 (4 weeks; 2 weeks after action plans)

\* Excluded from the meta-analysis. Abbreviations: FFQ = Food Frequency Questionnaire. In this table a positive Cohen's *d* is indicative of an increase in healthy eating behaviour and supports the effectiveness of the intervention.

Table 3

A summary of the papers included for the effect of Implementation intentions on reducing *unhealthy eating behaviours*.

	Training condition	Control condition	Session(s)	Time between plan and outcome	Behavioural outcome	Participants	Effect size
Achtziger et al. (2008) Study 1	Implementation intentions	Control	1	1 week	Two open-ended items; Change in the number of specified snack foods consumed in the past week	92 undergraduate students	−0.41
Adriaanse et al. (2009) Study 1	Implementation intentions with a motivational cue	Control	1	Directly after manipulation (for 7 consecutive days)	Food diary for 7 consecutive days; mean number of calories of consumed unhealthy snacks a day	108 female students	−0.09
Adriaanse et al. (2009) Study 2	Implementation intention with a personal motivational cue	Control	1	Directly after manipulation (for 7 consecutive days)	Food diary for 7 consecutive days; mean number of unhealthy in kcal snacks a day	72 female students	−0.62
Adriaanse et al. (2010) Study 1	Implementation intention with mental contrasting	Control (made a list of top 10 healthy snacks)	1	Directly after manipulation (for 7 consecutive days)	Food diary for 7 consecutive days; sum of kcal for unhealthy snacks in past week	51 female students	−0.82
*Adriaanse et al. (2010) Study 2	Implementation Intention with mental contrasting	Mental contrasting only	1	1 week	Success of reducing unhealthy snack habit rated on 7 Point Likert Scale (3 items)	59 female participants	0.75

Table 3 (Continued)

	Training condition	Control condition	Session(s)	Time between plan and outcome	Behavioural outcome	Participants	Effect size
Adriaanse et al. (2011a) Study 3	Replacement implementation intentions	Intention only (I will not eat chocolate)	1	Directly after manipulations (for 7 consecutive days)	Snack diary for 7 consecutive days; Assessing the frequency of unhealthy snacking over the past week and Kcal consumed in the past week (for unhealthy snacks only)	130 female students	−0.23
Armitage (2004)	Implementation intention	Control	1	1 month	Fat intake (in grams) a day (calculated using a self-report food frequency instrument; report food over the past month)	264 participants	−0.34
de Vries et al. (2008)	Tailored health information letter plus Implementation intentions	Tailored health information letter only	3 × 1 (letters; only action planning in last letter)	9 months	Fat intake in grams (calculated from self-reported intake of 19 possible products or product groups)	2827 participants recruited through Dutch National Telephone Survey	0.06 (Derived from paper)
Karimi-Shahanjari et al. (2013)	Implementation intentions plus Theory of Planned Behaviour	Control	3 × 90 min	10 days 3 months	FFQ (Iranian version) assessing the number of unhealthy snacks (22 options) over the past week	739 adolescent girls	−0.52 −0.32
Knäuper et al. (2011b)	Implementation intention plus activity imagery	Goal intention control condition (form a goal to reduce craving without concrete strategy)	1	1 to 4 days after manipulation	Log sheets for craving for 4 consecutive days; number of servings of the food/drink participants consumed	119 participants (students and staff University)	−0.07
Kroeze et al. (2011) Study 2	Implementation intention	Control	1	1 week	Single open-ended item: Average chocolate consumption a day over the past week	56 female participants	−0.46
Luszczynska et al. (2007a)	Implementation intentions	Control	1	6 months	Daily saturated fat intake; measured using Meat Snack section of Rapid Food Screener	130 cardiac patients	−0.56
Prestwich et al. (2008)	Reasoning implementation intentions plus self-efficacy (protection motivation message)	Control	1	1 month	Saturated fat intake (as a percentage of total self-reported food intake) over the past month; measured using Meat Snack section of Rapid Food Screener	210 participants	−0.49
Prestwich et al. (2014)	Collaborative implementation intentions	Control	1	1 month 3 months 6 months	Fat intake (as a percentage of total self-reported food intake) over the past month; measured using Meat Snack section of Rapid Food Screener	393 participants	0.09 −0.02 0.05
Scholz et al. (2013)	Implementation intentions	Control	1 group session (supervised) and 8 consecutive sessions by mail	4 months 6 months 12 months After baseline assessment	Fat consumption in grams assessed by 24 h recall by structured interviews	373 individuals with BMI > 25	0.11 −0.09 0.01
Sullivan and Rothman (2008)	Implementation intentions	Control	1	1 week 2 weeks	Caloric intake (kcal) Fat intake (grams); Measured by 1 week recall using the self-report Eating habits Measure	145 students	Caloric intake −0.41 −0.33 Fat intake −0.26 (1 week) −0.35 (2 weeks)

Table 3 (Continued)

	Training condition	Control condition	Session(s)	Time between plan and outcome	Behavioural outcome	Participants	Effect size
van Koningsbruggen et al. (2011) Study 2	Think of dieting implementation intention	No-treatment control condition	1	2 weeks	Mean rating of frequency and amount of 5 critical food items averaged (using a 7 points Likert Scale)	236 participants	−0.43
van Koningsbruggen et al. (2014) Study 1	No-go task plus diet primed implementation intentions	Control (implementation intentions on non-food items only)	1 (for no go task; 12 (6 trials each)	1 day	Mean standardised amount of sweets (weight and size) obtained from a food serving behaviour measure with a sweet-shop like environment	89 participants	−0.58
*van Koningsbruggen et al. (2014) Study 2	No-go task plus diet primed implementation intentions	Control (implementation intentions on non-food items only)	1 (for no go task; 12 (6 trials each)	The same day (after fulfilling a word completion task)	Average amount of selected portion size in computerised snack dispenser (0–500)	88 students in social sciences	−0.53
*Zhang and Cooke (2012)	Implementation intentions plus self-efficacy (through use of protection motivation messages)	Control	2 × 1 (first session focused on motivational intervention; second on volitional)	4 weeks (motivation; 2 weeks after volitional)	Fat intake percentage of total food intake measured by adapted form of the FFQ	84 students	−1.26 (4 weeks; 2 weeks after action plans)

\* Excluded from meta-analysis. Abbreviations: FFQ = Food Frequency Questionnaire. In this table a negative Cohen's *d* is indicative of a decrease in unhealthy eating behaviours and supports the effectiveness of the intervention.

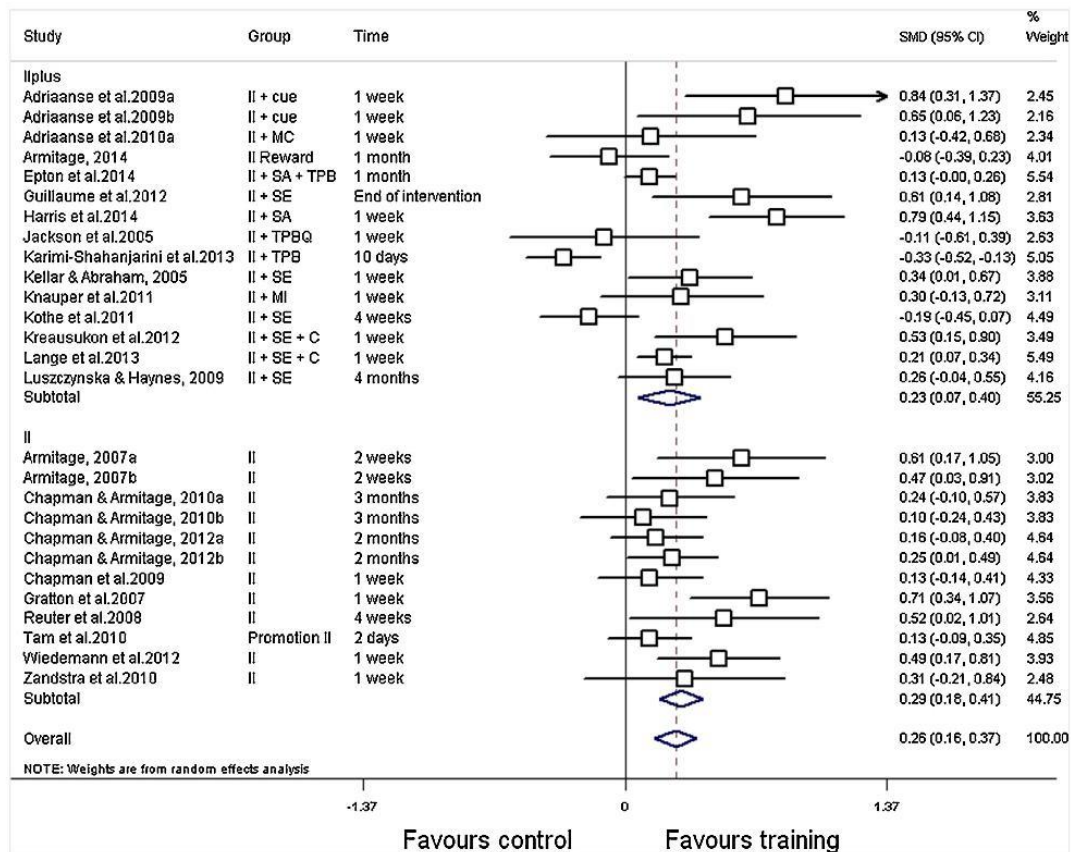
Table 4

A summary of the papers included for the effect of Implementation intentions on changing weight.

	Training condition	Control condition	Session(s)	Time between plan and outcome	Behavioural outcome	Participants	Effect size (Cohen's <i>d</i> )
Epton et al. (2014)	Online intervention based on implementation intentions, a self-affirmation task and theory of planned behaviour messages	Control	Provided in app (participants could sign up for email reminders; read the interventions numerous times)	1 month	BMI	1445 students (recruited 2 weeks prior to start of University year)	0.17
				6 months			0.06
				After starting University (still enrolled in intervention)			
*Luszczynska and Haynes (2009)	Implementation intentions and self-efficacy	Control	3 (directly after measurement, after 6 and 9 weeks)	4 months first implementation intention	BMI (self-report)	182 students (46% BMI > 25)	−0.29
Luszczynska et al. (2007b)	Implementation intentions	Control	8 (2 months; 1 supervised)	2 month after baseline assessment	BMI (computed in weight-loss program)	50 overweight and obese women	−0.31
					Body weight (kg; computed in weight-loss program)		−0.14
Prestwich et al. (2014)	Collaborative implementation intentions	Control	1	6 months	Body weight (kg); self-report	427 participants	0.16
Veling et al. (2014)	Implementation intentions plus food no-go training	Control (no implementation intentions and no go training without food pictures)	4	4 to 5 weeks from baseline assessment (after 4 weeks of training)	Weight loss in kg (session 1–session 2)	113 participants	−0.13
Zandstra et al. (2010)	Implementation intentions	Control	1	4 weeks	BMI; self-reported	57 overweight consumers using a website on meal replacement foods	−0.45

\* Excluded from meta-analysis; Abbreviations: BMI = Body Mass Index; kg = kilograms. Hereby, a negative Cohen's *d* is indicative of a decrease in weight and supports the effectiveness of the intervention.

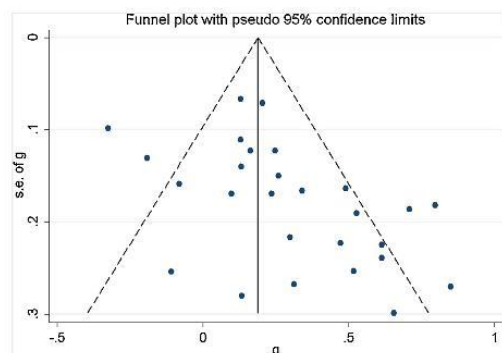




**Fig. 4.** A forest plot for the effectiveness of the implementation intention approach for increasing healthy eating. Abbreviations: II = implementation intentions; MC = mental contrasting; SA = self-affirmations; TPB = theory of planned behaviour; SE = self-efficacy; TPBQ = Theory of Planned Behaviour Questionnaire; MI = mental imagery; C = coping planning.

Heterogeneity was found to be moderate ( $I^2 = 58.2\%$ ). A further inspection of the subgroups revealed that the implementation intention only subgroup showed no heterogeneity ( $I^2 = 0.0\%$ ) while in the implementation plus group heterogeneity was found to be

$I^2 = 66.9\%$ . Therefore, a meta-regression was performed in which intervention type was entered. However, intervention type was not found to significantly explain the heterogeneity of the studies ( $p = 0.343$ ).



**Fig. 5.** A funnel plot to assess publication bias for studies examining the effect of implementation intentions on increasing healthy food intake.

### 3.1.3. Implementation intentions aimed at reducing unhealthy food intake

Four studies were excluded from the analysis for several reasons: standard deviations and/or means of the data were not reported (de Vries et al., 2008); the dependent variable was formulated as the success rate of reducing unhealthy food intake (Adriaanse et al., 2010; Study 2); the primary outcome was a computerised measure rather than actual food intake (van Koningsbruggen et al., 2014, Study two); and the study of Zhang and Cooke (2012) was excluded for the same reason as for the effect of implementation intention on increasing healthy food intake.

Fifteen studies were included in the forest plot (please refer to Fig. 8). Participants in the implementation intention group reduced their unhealthy food intake with a small effect size of  $-0.31$  (95% CI:  $-0.44$  to  $-0.19$ ). We found no evidence for publication bias (Begg's test  $p = 0.544$ ; Egger's test  $p = 0.970$ ). Heterogeneity was found to be moderate for the total sample ( $I^2 = 47.3\%$ ). Further inspection of the subgroups suggests that this heterogeneity was mainly due to

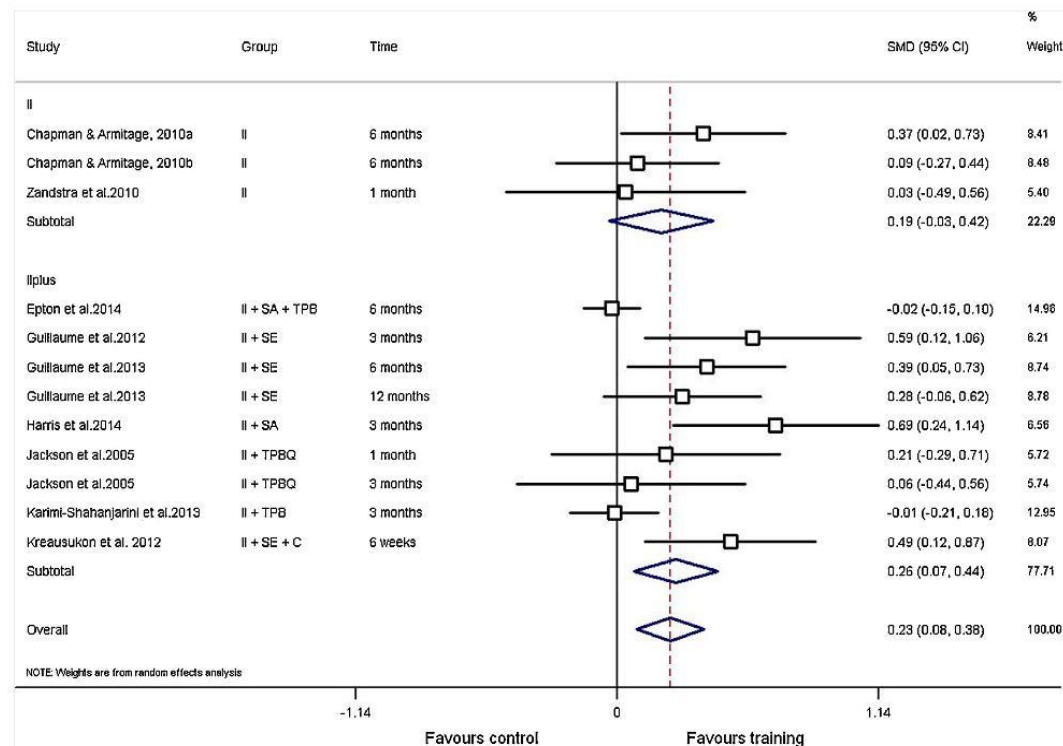


Fig. 6. A forest plot for the effect of the implementation intention approach for increasing healthy eating at follow-up. Abbreviations: II = implementation intentions; SA = self-affirmations; TPB = theory of planned behaviour; SE = self-efficacy; TPBQ = Theory of Planned Behaviour Questionnaire; C = coping planning.

the moderate to high heterogeneity in the implementation intention plus group ( $I^2 = 68.2\%$ ) compared to the small heterogeneity in the implementation intention only group ( $I^2 = 11.7\%$ ). Therefore, a meta-regression was performed in which type of implementation intention intervention was entered as variable. Type of intervention did not significantly explain the variance although a trend was indicated ( $p = 0.083$ ).

Four studies had outcomes measured at follow-up and were included in the forest plot shown in Fig. 9. People in the implementation intention group were slightly more successful in reducing unhealthy food intake with a small effect size of  $-0.16$  (95%

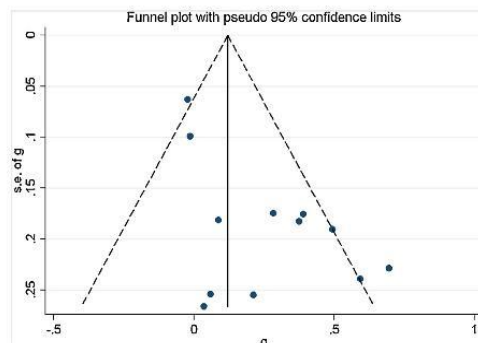


Fig. 7. A funnel plot to assess publication bias at follow-up for the implementation intention approach for increasing healthy eating.

CI:  $-0.29$  to  $-0.02$ ) relative to the control groups. We found no evidence for publication bias (Begg's test  $p = 0.548$ ; Egger's test  $p = 0.463$ ) or heterogeneity ( $I^2 = 35.3\%$ ). The data in the forest plot were ordered by time at follow up, and visually this suggests the effect of implementation intention on reducing unhealthy food intake declines with time.

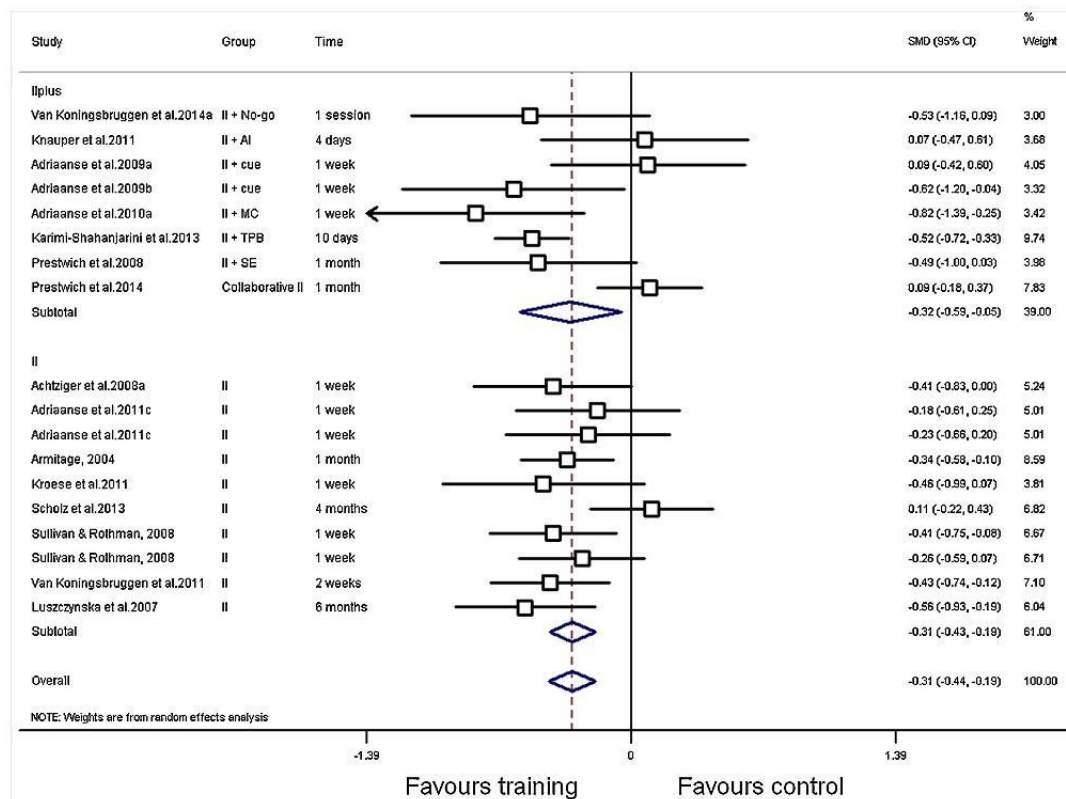
### 3.1.4. Implementation intentions aimed at changing weight

One study was excluded from the meta-analysis (Luszczynska and Haynes, 2009) because data including standard deviations and/or means were not reported pre- and post-intervention. Five studies were included in the forest plot (please refer to Fig. 10). The overall effect size of implementation intentions for changing weight (effect size =  $0.04$ ; 95% CI:  $-0.08$  to  $0.17$ ) or BMI,  $0.09$  (95% CI:  $-0.06$  to  $0.23$ ) was negligible. In regards to the effectiveness of implementation intentions in changing weight (kg), the effect size was also found to be small ( $-0.07$ ; 95% CI:  $-0.35$  to  $0.20$ ). No evidence for heterogeneity was found ( $p = 0.15$ ,  $I^2 = 36.1$ ). The Begg's ( $p = 0.37$ ) and Egger's tests ( $p = 0.051$ ) were performed to examine for publication bias. Due to the Egger's test being close to statistical significance a funnel plot was created (Fig. 11). This highlighted that there may be a lack of small sized studies that do not support the impact of implementation intentions on weight.

### 3.2. The effect of food-specific inhibition training on reducing unhealthy food intake

For a summary of the papers found for food-specific inhibition training please refer to Table 5. Eight studies were excluded from





**Fig. 8.** A forest plot for the implementation intention approach for decreasing unhealthy eating post-intervention. Abbreviations: II = implementation intentions; MC = mental contrasting; TPB = theory of planned behaviour; SE = self-efficacy; AI = activity imagery.

the meta-analysis for a variety of reasons: the primary outcome was a computerised measure rather than actual food intake (van Koningsbruggen et al., 2014, Study two; Veling et al., 2013b, Study 1 and Study 2); it was the only study considering weight change (Veling et al., 2014); or the inhibition training was not food-specific (Guerrieri et al., 2009, Study 1 and Study 2; Guerrieri et al., 2012; Lawrence et al., 2015, Study 3). Five studies were included in the meta-analysis forest plot (please refer to Fig. 12).

Stop-signal training produced a small to medium reduction in food intake (effect size of  $-0.39$  (95% CI:  $-0.67$  to  $-0.11$ ). Go/no go training produced a medium effect size in reducing food intake ( $-0.58$ , 95% CI:  $-0.97$ ,  $-0.19$ ). Overall, food-specific inhibition training had an effect size of  $-0.46$  (95% CI:  $-0.67$ ,  $-0.25$ ) in reducing food intake. A non-significant small amount of heterogeneity was found for the go/no go approach ( $I^2 = 33.6\%$ ). There was evidence of publication bias (Begg's test  $p = 0.024$ ; Egger's test  $p = 0.012$ ). Funnel plots were performed (Fig. 13) which highlighted that there may be a small amount of publication bias; relating to a lack of small sized studies that do not support the effectiveness of food-specific inhibition training. Only one study (Veling et al., 2014) examined weight change during four weeks of internet delivered food-specific inhibition training and found no effect ( $d = 0.03$ ). Overall, based on Fig. 13, there also appears to be a lack of large sized studies examining the effects of food-specific inhibition training.

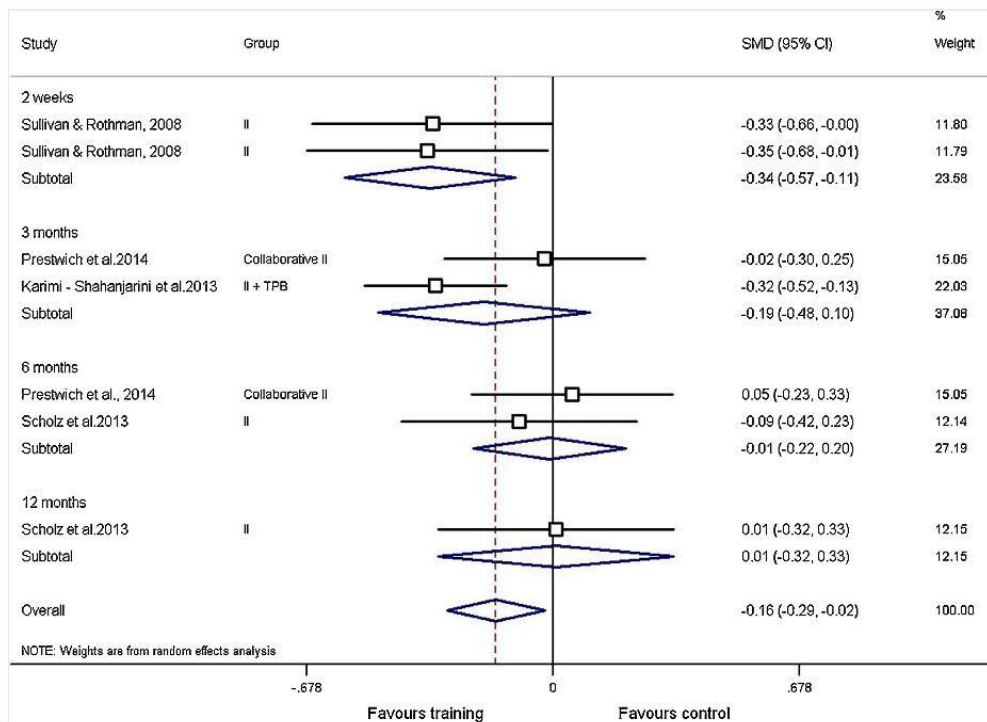
### 3.3. The effect of attention bias modification

#### 3.3.1. Overview of included studies

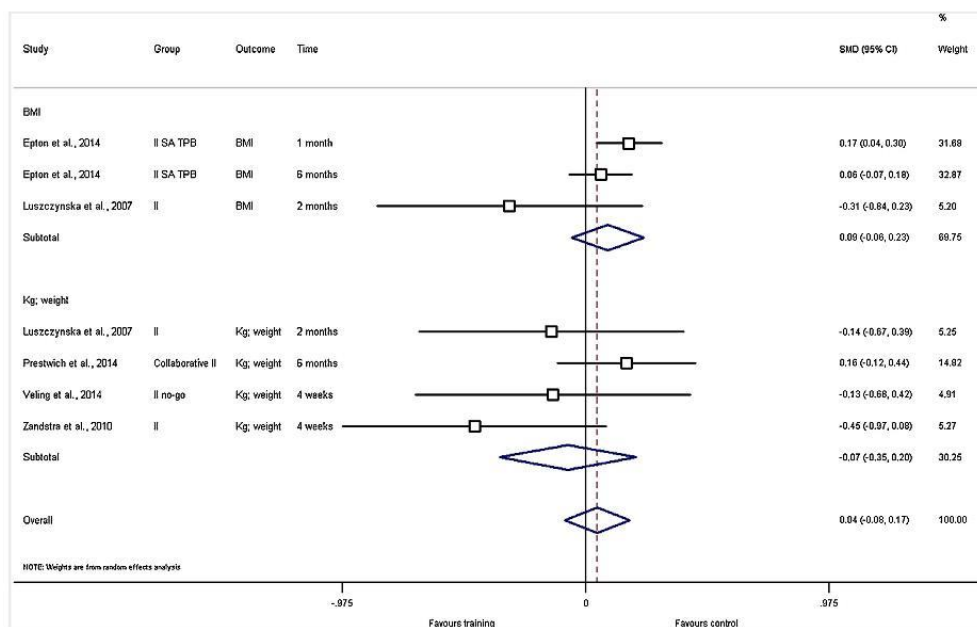
In total six studies were found: (1) ( $n = 4$ ) reducing unhealthy food intake (Table 6); (2) ( $n = 2$ ) increasing healthy food intake (Table 7); and (3) ( $n = 2$ ) increasing unhealthy food intake (Table 8). A meta-analysis was only completed for the effect of attention bias modification in reducing unhealthy food intake only due to the limited number of studies found for the other two groups. The limited amount of evidence found so far has indicated that attention bias modification might be useful in increasing healthy food intake. Kakoschke et al. (2014) found a moderate effect size of 0.36 for increasing healthy food intake. In regards to increasing unhealthy food intake, a mean effect size of 0.18 has been found from the two studies conducted to date (Hardman et al., 2013; Werthmann et al., 2014).

#### 3.3.2. Attention bias modification aimed at reducing unhealthy food intake

Four studies were included in the meta-analysis (please refer to Fig. 14). Overall, attention bias modification had an effect size of  $-0.51$  (95% CI:  $-0.80$ ,  $-0.22$ ) in reducing unhealthy food intake. A significant small amount of heterogeneity was found overall ( $I^2 = 25.9\%$ ). There was no evidence of publication bias (Begg's test  $p = 0.734$ ; Egger's test  $p = 0.138$ ).



**Fig. 9.** A forest plot for the implementation intention approach for reducing unhealthy eating at follow-up. Abbreviations: II=implementation intentions; TPB = theory of planned behaviour.



**Fig. 10.** A forest plot to show the effectiveness of the implementation intention approach for changing weight. Abbreviations: II=implementation intentions; SA = self-affirmations; TPB = theory of planned behaviour.

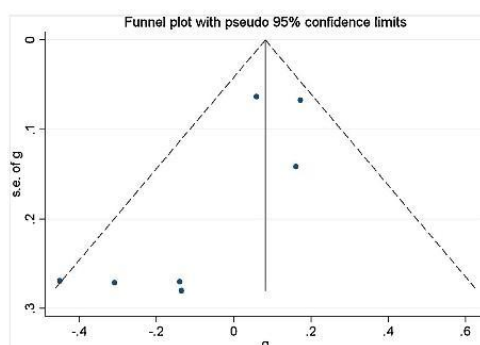


Fig. 11. A funnel plot to examine for publication bias for implementation intentions to change weight post-intervention.

Table 5

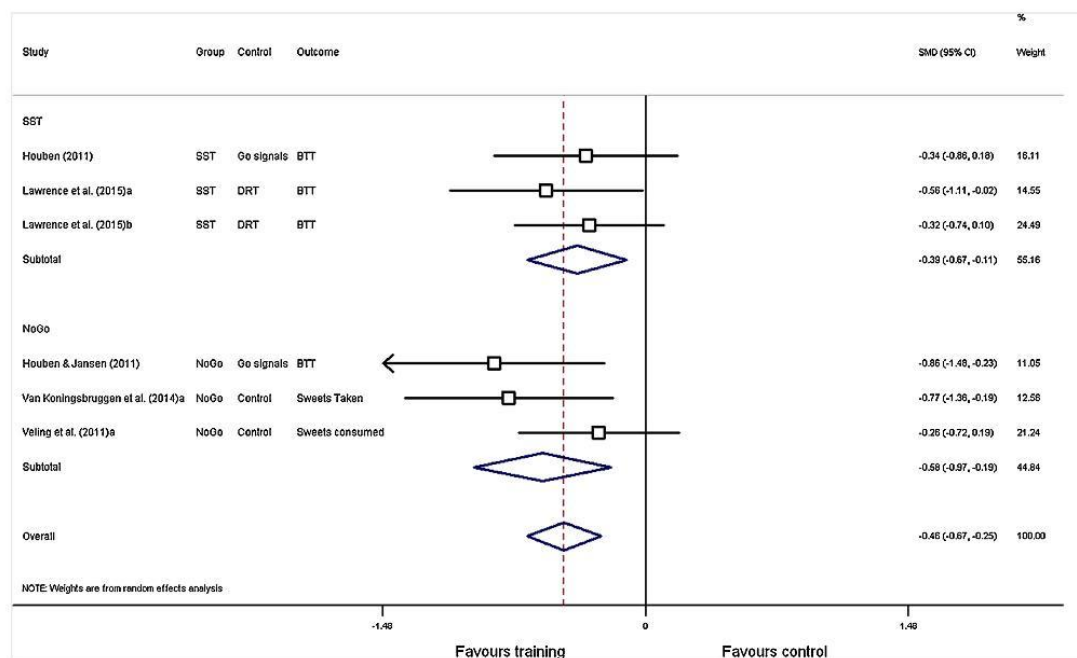
A summary of the included papers for the effect of food-specific inhibition training on reducing unhealthy food intake.

	Training condition	Control condition	Session(s); trials in each session	Behavioural outcome	Participants	Effect size (Cohen's <i>d</i> )
<sup>a</sup> Guerrieri et al. (2009) Study one	An inhibition priming task	An impulsivity priming task	1; 1	Amount of food intake on a bogus taste test	46 female undergraduates	NR
<sup>a</sup> Guerrieri et al. (2009) Study two	Stop-signal task: training inhibition by instructing participants to focus on stopping	Stop-signal task: training impulsivity by instructing participants to focus on speed	1; 96	Amount of food intake on a bogus taste test	46 female undergraduates	NR
<sup>a</sup> Guerrieri et al. (2012)	Stop-signal task: the no. of stop trials rose by 5% in each block	Reading two neutral stories	1; 600	Amount of food intake on a bogus taste test	61 female undergraduates	NR
Houben (2011)	High calorie food paired with a stop signal	High calorie food paired with go signal on half the trials	1; 288	Calories consumed on a bogus taste test	29 female undergraduates	−0.34
Houben and Jansen (2011)	Go/no go task: Chocolate paired with a no-go	Chocolate paired with go signal on half the trials	1; 320	Amount of chocolate consumed	63 female undergraduates	−0.86
Lawrence et al. (2015) Study one	Stop-signal task: snacks paired with a stop signal	Double response training (participants had to give an additional response (pressing the space bar) on signal trials); snacks paired with a stop signal	1; 480	Amount of crisp consumption	54 students/staff members	−0.56
Lawrence et al. (2015) Study two	Stop-signal task: snacks paired with a stop signal	Double response training	1; 512	Amount of crisps or chocolate consumed during the bogus taste test	136 students/staff members	−0.32
<sup>a</sup> Lawrence et al. (2015) Study three	Stop-training—one non-food category always linked to stop	Double response training	1; 512	Amount of crisps or chocolate consumed during the bogus taste test	146 students/staff members	0.01
van Koningsbruggen et al. (2014) Study one	Go/no go task: sweets paired with no-go signal	Sweets not paired with no-go signals	1; 72	Mean standardised amount of sweets (weight and size) obtained from a food serving behaviour measure with a sweet-shop like environment	89 students	−0.77
<sup>a</sup> van Koningsbruggen et al. (2014) Study two	Go/no go task: sweets paired with no-go signal	Sweets not paired with no-go signals	1; 72	The number of snacks requested on a computerised snack dispenser task	88 students	−0.74
Veling et al. (2011a) Study two	Go/no go task: sweets were paired with no-go signal	Sweets not paired with no-go signals	1; 72	Lower levels of sweet consumption in a take home candy bag task	46 undergraduate students	−0.26

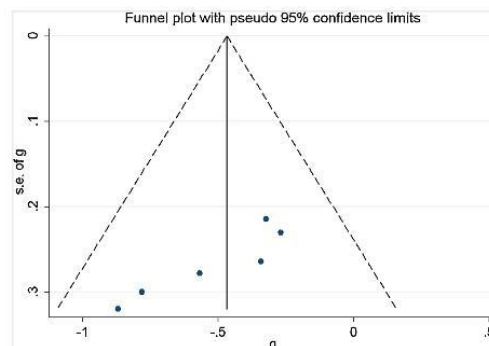
Table 5 (Continued)

	Training condition	Control condition	Session(s); trials in each session	Behavioural outcome	Participants	Effect size (Cohen's <i>d</i> )
<sup>a</sup> Veling et al. (2013b) Study one	Stop-signal task: snacks paired with no-go signal	Go signals were paired with snacks	1; 96	Number of choices of unhealthy foods on a computerised task	79 young adults	−0.53
<sup>a</sup> Veling et al. (2013b) Study two	Stop-signal task: Snacks paired with no-go signal	Go signals were paired with snacks	1; 96	Number of choices of unhealthy foods on a computerised task (Extra condition is frequency of past behaviour scores)	44 young adults	−0.71
<sup>a</sup> Veling et al. (2014)	Stop-signal task: snacks paired with no-go signal	Neutral pictures linked with no-go signal	4 (1 per week over 4 weeks); 200	Weight loss in kilogram's between the start and end of study	113 participants	0.03

<sup>a</sup> Excluded from the meta-analysis. For this approach a negative Cohen's *d* is indicative of a reduction in unhealthy food intake/weight and supports the effectiveness of the intervention.



**Fig. 12.** Forest plot to show the effectiveness of food-specific inhibition training to reduce food intake. Abbreviations: SST = stop signal training; BTT = Bogus taste test; DRT = double response training.



**Fig. 13.** Funnel plot for the meta-analysis of food-specific inhibition training on reducing unhealthy food.



**Table 6**

A summary of the papers included for the effect of attention bias modification training on reducing unhealthy food intake.

	Training condition	Control condition	Session(s); No. of trials	Behavioural outcome	Participants	Effect size
Boutelle et al. (2014)	Trained attention 100% of the time from food words to neutral words	Attention was trained 50% to neutral and 50% to food stimuli	1; 288	Amount of calories consumed in a test meal	29 overweight obese children	−0.27
Hardman et al. (2013)	Training attention away from cake stimuli	Attention was trained 50% to neutral and 50% to food stimuli	1; 768	Amount of the target food (i.e., cake) and non-target food (i.e., crisps)—measured in kcal	60 undergraduate students	−0.04
Kemps et al. (2014b) Study one	Avoid chocolate stimuli	Training attention towards chocolate stimuli	1; 140	Amount of chocolate muffin consumed in a taste test	110 female undergraduate students	−0.67
Kemps et al. (2014b) Study two	Avoid chocolate stimuli	Training attention towards chocolate stimuli	1; 140	Amount of chocolate muffin consumed in a taste test	88 female undergraduates	−0.71

For this approach a negative Cohen's *d* suggests a reduction in unhealthy food intake and supports the effectiveness of the intervention.

**Table 7**

A summary of the papers found examining the effect of attention bias modification training on increasing healthy food intake.

	Training condition	Control condition	Session(s)	Behavioural outcome	Participants	Effect size (Cohen's <i>d</i> )
*Kakoschke et al. (2014)	Training attention towards healthy food stimuli	Training attention towards unhealthy food stimuli	1; 512	Amount of food consumed on a bogus taste test	146 female undergraduate students	0.36
*Smith and Rieger (2009)	Attend to low calorie food	Neutral	1; 240	Food selection task (as a measure of dietary restriction)	98 female undergraduates	NR

\* Excluded from the meta-analysis. For this approach a positive Cohen's *d* suggests an increase in healthy food intake and supports the effectiveness of the intervention.

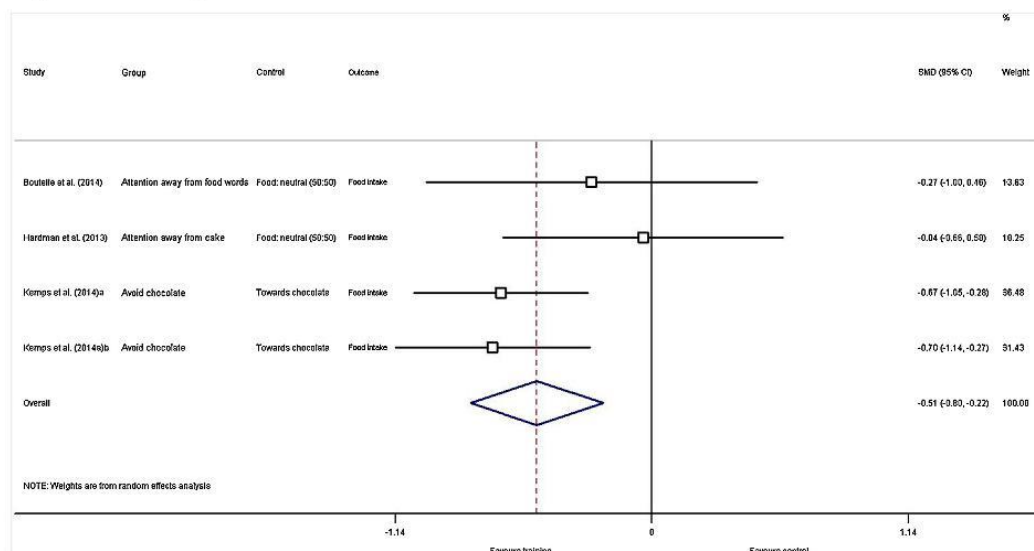
**Table 8**

A summary of the papers found examining the effect of attention bias modification training on increasing unhealthy food intake.

	Training Condition	Control condition	Session(s)	Behavioural outcome	Participants	Effect size (Cohen's <i>d</i> )
*Hardman et al. (2013)	Training attention towards cake stimuli	Attention was trained 50% to neutral and 50% to food stimuli	1; 768	Amount of the target food (i.e., cake) and non-target food (i.e., crisps)—measured in kcal	60 undergraduate students	0.34
*Werthmann et al. (2014)	Attend to chocolate and away from neutral stimuli (i.e., shoes) <sup>a</sup>	Attend to neutral stimuli (i.e., shoes) and away from chocolate	1; 320	Amount of chocolate consumed in a taste test	56 female undergraduate students	0.02

\* Excluded from the meta-analysis. For this approach a positive Cohen's *d* is indicative of an increase in unhealthy food intake and supports the effectiveness of the intervention.

<sup>a</sup> Werthmann et al. (2014) used a novel version of an antisaccade task to modify attention. In this task participants were instructed to direct their eye movements either towards or away from an onscreen target stimulus.

**Fig. 14.** A forest plot to show the effectiveness of attention bias modification in reducing unhealthy food intake.

#### 4. Discussion

##### 4.1. Summary of the results

The aim of this review was to examine the effectiveness of approaches that may be beneficial for developing healthier eating habits in eating and weight disorders. A primary finding from this review is that no studies using these approaches in clinical populations with AN, BN and BED were found in the literature. This was surprising considering the recent formulations of these illnesses based around habit-theory and impulsivity and/or compulsivity (Robbins et al., 2012; Treasure et al., 2014; Walsh, 2013). A limited number of studies using the implementation intention approach with overweight/obese individuals were found. The implementation intention approach was found to have small effect sizes post-intervention in increasing healthy food intake and reducing unhealthy food intake with negligible effects at follow-up respectively. More promisingly, medium effect sizes were found for the impact of food-specific inhibition training and attention bias modification in reducing unhealthy food intake. Caution may be taken in making any definite conclusions regarding the effectiveness/clinical application of these approaches though due to the moderate to high level of heterogeneity found in the data for the implementation intention approach and the limited number of studies over the follow-up period examining food-specific inhibition training and attention bias modification.

A previous meta-analysis that focused on the implementation intention approach (Adriaanse et al., 2011b), found a larger effect size for increasing healthy food intake ( $d=0.51$ ) compared to the present study. A possible explanation for the smaller effect size found in this review may be due to the more stringent inclusion criteria followed in this review. For instance, (Adriaanse et al., 2011b) stated that their finding might have been inflated due to the poor quality of control conditions included in the review. Furthermore, the present study excluded correlational studies meaning that the inclusion of studies that involved the random allocation of participants to an experimental or control condition may have led to a more valid effect size being found. This was done in order to specifically address the question of whether these approaches might be beneficial as interventions for developing healthier eating habits in clinical populations. The result from this review that the implementation intention approach also has a small effect size in reducing unhealthy food intake is similar to the small effect size ( $d=0.29$ ) reported by Adriaanse et al. (2011b). This review extended this finding by also examining follow-up data that suggested that over a one-year period the small effect of implementation intentions in reducing unhealthy food intake diminishes. To date this is the first review to systematically examine the effectiveness of food-specific inhibition and attention bias modification training.

##### 4.2. Implications of the findings

The finding from this review that the implementation intention approach has a small effect size in increasing or reducing food intake suggests that when used alone this approach may not be successful in helping individuals to develop healthier eating habits (Verplanken and Wood, 2006). It is conceivable that if implementation intentions are to be used in the treatment of AN they may be of most benefit when used in conjunction with other approaches such as the self-monitoring techniques used in CBT. This may allow for the identification of maladaptive habits which implementation intentions may then be targeted at (Lally and Gardner, 2011). It may also be hypothesised that implementation intentions may most beneficial at the earlier stages of treatment than in the severe and enduring stage of AN whereby eating habits are more compulsive and resistant to change (Steinglass and Walsh, 2006; Treasure et al.,

2014; Walsh, 2013). At this earlier stage of illness, implementation intentions could be most likely to help prevent the development of fixed eating habits. However, this hypothesis needs testing.

Implementation intentions might also be most effective when combined with other interventions in obesity, BED and BN. Research has found that the effectiveness of implementation intentions' is moderated by the trait of impulsivity (Churchill and Jessop, 2011). This trait has been found to be elevated in individuals with obesity, BED and BN (Claes et al., 2005; Mobbs et al., 2010) meaning that it may be beneficial to combine implementation intentions with other interventions that increase participants' levels of self-control such as food-specific inhibition training. A limited amount of research in non-clinical populations has not found additive effects of combining implementation intention and food-specific inhibition training approaches such as the go/no-go task (van Koningsbruggen et al., 2014; Veling et al., 2014). However, these studies have focused on undergraduate student samples and do not assess the long-term impact of the training on eating behaviour. Further research may be beneficial in clinical populations (i.e., obesity, BED and BN) to further elucidate whether combining implementation intention with self-control interventions is beneficial. This might employ other types of food-specific inhibition training than the go/no-go task such as the stop-signal task.

In the present review the effect of implementation intentions in reducing unhealthy food intake was found to diminish over time. One reason why behaviour change interventions may fail longitudinally is that although behaviours change can occur in the short-term, environmental and contextual cues may trigger unwanted habits to recur (Wood and R  nger, 2015). Walker et al. (2014) suggests that when developing a new habit there is an initial "window of opportunity for change" that is then followed by a "window of vulnerability to relapse" (p.12) as the unhealthy habit may not be entirely extinguished for at least four weeks. One method to increase the effectiveness of implementation intentions over time could be to use reminders of implementation intention plans (e.g., via text-message post-study; Prestwich et al., 2009) or to offer booster sessions of implementation intention training post-intervention. Another helpful approach to help prevent old habits from recurring might be to combine the implementation intention approach with attention-bias modification to help reduce the saliency of environmental cues that may trigger old unwanted habits such as unhealthy eating. This could possibly help maintain the development of new healthy habits.

The approaches of food-specific inhibition training and attention bias modification were found to have medium effects sizes in reducing food intake in healthy populations. These training paradigms could be useful for increasing self-control over highly palatable foods in obesity, BED and BN. Strengths of these approaches are that they may be widely disseminated and cost-effective with the potential for them to be used alongside existing psychological interventions. For instance, in substance use disorder attention bias modification approaches may be optimised by combining them with motivational support interventions (Boffo et al., 2015; Wiers et al., 2013). This approach might be beneficial for treatment resistant patients with eating disorders that have difficulties engaging with traditional 'talking therapies' or who have low levels of motivation to change (Renwick et al., 2013).

##### 4.3. Methodological considerations and limitations of the review

It should be noted that there are limitations to the literature in this review. Studies examining the effectiveness of food-specific inhibition training and attention bias modification training have been conducted in highly controlled laboratory settings. Consequently, the long-term effectiveness of these approaches on eating



behaviour in real-life settings appears unclear. Although the results appear promising for the effectiveness of the food-specific inhibition training and attention bias modification approach on reducing food intake, caution may also be taken in interpreting these findings due to the scarcity of studies using these approaches and the different control conditions used by studies. Due to the limited amount of literature a meta-analysis could not be performed to examine the effectiveness of attention bias modification training to increase healthy or unhealthy food intake.

This review focused on the primary effects of the different training approaches. Research has indicated that individual differences such as levels of dietary restraint might impact upon the effectiveness of food-specific inhibition training (Lawrence et al., 2015). In regards to attention bias modification training, another factor that could moderate the impact of the training is participant's accuracy of responses on the task (as measured through the use of eye-tracking technology; Werthmann et al., 2014). Consequently, future endeavours could seek to examine the impact of moderating variables on the different training approaches. This would help to indicate whom the training approaches might be most beneficial for.

Another consideration that should be taken into account is the relatively heterogeneous and diverse groups/populations surveyed across the studies included in this review. For example, the meta-analysis into the effectiveness of attention bias modification in reducing unhealthy food intake included both child (Boutelle et al., 2014) and adult samples (e.g., Hardman et al., 2013). Although studies are appearing to suggest that attentional biases towards food stimuli are evident in obese children, the strength of the available evidence at present may be considered greater for adults (Boutelle et al., 2014). Accordingly, further research into attention bias modification in both children and adult samples could help to clarify whether the findings of this present review are replicated in more homogenous samples. Before this occurs, caution may be taken in interpreting the promising preliminary findings of this review.

#### 4.4. Directions for future research in clinical populations

Given the finding that there is currently a lack of studies in clinical populations further research is needed that examines the effectiveness of the different training approaches in eating and weight disorders. This proof of concept work may help to experimentally assess whether these preliminary findings translate to clinical populations whereby eating disorder habits are more severe and long-standing.

In substance use disorder it has been suggested that it may be beneficial to tailor training approaches such as attention bias modification and inhibition training to the individual in order to gain more potent effects (Wiers et al., 2013). In eating disorders these approaches could also be tailored so that they are disorder-specific. For instance, clinically meaningful distinctions have been reported between binge eating episodes and overeating episodes without a sense of loss of control or emotional distress. Therefore, it could be beneficial to adapt approaches such as food-specific inhibition for individuals with BED or BN so that they are helpful when experiencing negative affect. The stimuli used in the training approaches could also be tailored towards an individual's specific 'trigger' foods for binge eating in these illnesses (Juarascio et al., 2015).

This present review has primarily focused on developing healthier eating habits through the use of cognitive/behavioural approaches. Habit based interventions could also be of benefit in the treatment of other compulsive behaviours in eating and weight disorders such as over-exercising, body checking and purging. For instance, implementation intentions could be adapted to help reduce purging behaviours (e.g., If I feel overwhelmed with the urge to purge after dinner, then I will call up my family for support).

Attention bias modification training away from body-related cues may also be beneficial to reduce body checking (Smeets et al., 2011). Novel pharmacological and neuromodulation approaches have also recently emerged as novel treatment approaches for eating disorders and may be helpful to target impulsive/compulsive systems in people with severe and enduring illnesses (McClelland et al., 2013; Oudijn et al., 2013; Treasure et al., 2015).

#### 4.5. Conclusion

To summate, there is preliminary evidence that implementation intentions, food-specific inhibition training and attention bias modification may change habitual eating behaviours in predominantly healthy populations. Before any firm conclusions can be drawn about the effectiveness of food-specific inhibition training and attention bias modification, further research is needed due to the current limited number of studies. Future studies may benefit from more rigorously designed control groups and longer-term follow-ups. This might lead to the development of interventions that could be of value in clinical populations.

#### Conflict of interest statement

The authors declare having no conflict of interests in the writing of this paper.

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## 7.1. Chapter summary

This systematic and meta-analytic review considered novel approaches to develop healthier eating habits for people with eating and weight disorders. Specifically, implementation intentions, food-specific inhibitory control training and attention bias modification. Implementation intentions were found to produce a small increase in ‘healthy’ food consumption (Cohen’s  $d = .26$ ) and decrease in high-calorie food consumption (Cohen’s  $d = -.31$ ). Moderate reductions in high-calorie food consumption were found for food-specific inhibitory control training (Cohen’s  $d = -.46$ ) and attention bias modification (Cohen’s  $d = -.51$ ). Therefore, these approaches may be promising methods to help people to develop healthier eating habits.

The review did highlight several limitations in the current evidence-base. Namely: 1) there has been no research in clinical populations to date; 2) there are a limited number of studies for the inhibitory control training and attention bias modification approaches; 3) there is a large variation in the control conditions used between studies; 4) there is a moderate to high level of heterogeneity for implementation intention studies; and 5) there is a paucity of long-term follow-up data. Nonetheless, as a result of the promising effects found in healthy populations, the following chapter of this thesis sought to build upon the existing evidence-base by piloting food-specific inhibitory control training for women with BN and BED. This approach was piloted due to the moderate effect size for a single session of training and due to the central role of cognitive control in maintaining binge-eating episodes (as reviewed in chapter six).

## Chapter eight:

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### Study four

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#### Based upon:

**Turton, R.,** Nazar, B., Burgess, E., Lawrence, N., Treasure, J., & Hirsch, C. (2018).  
To go or not to go: A proof of concept study testing food-specific inhibition  
training for women with eating and weight disorders, *European Eating  
Disorders Review*, 26 (1), 11-21. doi: 10.1002/erv.2566.

## 8.1. Abstract

Inefficient food-specific inhibitory control is a potential mechanism that underlies binge-eating in BN and BED. Go/ no-go training tools have been developed to increase inhibitory control over eating impulses. Using a within-subjects design this study examined whether one session of food-specific go/ no-go training, versus general inhibitory control training, modifies eating behaviour. The primary outcome measure was food consumption on a taste test following each training session. Women with BN and BED had small non-significant reductions in high-calorie food consumption on the taste test following the food-specific compared to the general training. There were no effects on eating disorder symptomatic behaviour (i.e., binge-eating/ purging) in the 24 hours post-training. The training task was found to be acceptable by the clinical groups. More research is needed with larger sample sizes to determine the effectiveness of this training approach for clinical populations.

## 8.2. Introduction

Inhibitory control is the ability to override an impulse or stop an initiated action and has been highlighted by the Research Domain Criteria as a ‘cognitive system’ that might underlie psychopathology across a range of mental illnesses (National Institute of Mental Health, 2016). Indeed, food-specific inhibitory control could be a mechanism that subserves binge-eating episodes in BN and BED (Pearson, Wonderlich, & Smith, 2015; Robbins, Gillan, Smith, de Wit, & Ersche, 2012; Turton, Chami, & Treasure, 2017). In support of this, a meta-analysis (Wu, Hartmann, Skunde, Herzog and Friederich, 2013) found impairments in inhibitory control towards food and eating stimuli in people with BN (moderate effect size: Cohen’s  $d = -.67$ ) and food-specific inhibitory control difficulties have also been reported for people with BED with this difficulty positively correlating with eating disorder psychopathology (Svaldi, Naumann, Trentowska, & Schmitz, 2014). It follows that improving food-specific inhibitory control might reduce binge-eating in BN and BED (Treasure, Cardi, Leppanen, & Turton, 2015).

Novel computerised go/ no-go training approaches have been created in which high-calorie foods always appear onscreen with no-go cues whereas other items (e.g., low-calorie foods/ non-food images) appear with go cues. It is hypothesised that the approach works by reducing automatic motor excitability towards high-calorie foods, increasing top-down inhibitory control and/or through food devaluation (e.g., Chen, Veling, Dijksterhuis, & Holland, 2016; Jones, Hardman, Lawrence, & Field, 2017; Veling, Lawrence, Chen, van Koningsbruggen, & Holland, 2017). Go cues can also be used to train disinhibition towards target stimuli (e.g., priming people towards alternate food choices; e.g., Blackburne, Rodriquez, & Johnstone, 2016).

Given this, in addition to improving food-specific inhibitory control, food devaluation could also be a helpful outcome of the training for people with eating disorders. This is because women with BN and BED have increased activation in the medial orbitofrontal cortex when receiving food rewards than weight-matched participants, which positively correlates with the tendency to eat in response to external food cues (Simon et al., 2016). High-calorie food cues have also been found to increase state food cravings in women with bulimic-type illnesses (Van den Eynde et al., 2012). These findings suggest that women with BN and BED may have stronger impulses towards these foods and therefore, may have stronger training effects than people without eating disorders.

Experimental studies have found that for restrained eaters a single session of training can reduce high-calorie food consumption in the laboratory (e.g., Adams, Lawrence, Verbruggen, & Chambers, 2017; Houben & Jansen, 2011; Lawrence, Verbruggen, Morrison, Adams, & Chambers, 2015b). Furthermore, Veling, Aarts and Papies (2011) reported that restrained eaters consume less no-go trained sweets in the 24 hours post-training, suggesting that the training also has an effect outside of the laboratory. For individuals who are overweight or obese, it has been found to increase low-calorie food consumption and reduce high-calorie food consumption (Blackburne, Rodriquez, & Johnstone, 2016), and to lower daily energy intake and ‘liking’ ratings of high-calorie foods (Lawrence et al., 2015a).

Meta-analyses of these studies have found that a single session of food go/no-go training produces moderate reductions (ranging from Cohen’s  $d = .47$  to  $.58$ ) in eating

high-calorie foods (Allom, Mullan, & Hagger, 2016; Jones et al., 2016; Turton, Bruidegom, Cardi, Hirsch, & Treasure, 2016). However, most of these studies were conducted in healthy and overweight individuals, and to date, no research has been published in populations with eating disorders. Given the evidence for impaired food-specific inhibitory control in BN and BED, and the promising results in healthy/overweight populations, a proof of concept study using a single-session of food go/no-go training in these patient groups seems warranted.

The aim of this proof of concept study was to compare the effect of a single session of food specific inhibition training with general inhibition training in women with BN and BED, using a within-subjects design. Our main hypothesis was that following the food-specific training participants with BN and BED would reduce their intake of high-calorie foods more than in the general training condition and increase low-calorie food consumption. Also, we investigated if overweight/obese women without eating disorders would follow the same behaviour alongside a lean control group. An exploratory hypothesis was that levels of food craving would predict stronger training effects. It was also speculated that eating disorder symptomatic behaviour (i.e., binge-eating/ purging) might decrease in the 24-hours post-training.

### **8.3. Materials and methods**

#### *8.3.1. Design*

Participants completed a single session of food-specific inhibition training and a general (non-food) version of the training using a within-subjects design. The order that participants completed the two conditions was counterbalanced, with the sessions scheduled approximately one week apart to minimise carryover effects. Participants received either the food or non-food inhibition training first (using the random number generator function in Microsoft Excel<sup>®</sup>) using a block randomisation approach.

### 8.3.2. *Participants*

Women with BN ( $N=30$ ) and BED ( $N=19$ ) were recruited from the South London and Maudsley eating disorder service, King's College Hospital (Endocrinology and Bariatric Surgery Clinic) and Vincent Square eating disorder service. Participants were also recruited through B-eat ([www.b-eat.co.uk](http://www.b-eat.co.uk)). Overweight/obese without an eating disorder and lean women were recruited through advertisements placed on the King's College London website and by fliers placed around campus. In total, 30 lean women (i.e., with a Body Mass Index (BMI) between 18.5 and 24.9) and 19 women with a BMI over 24.9 were recruited.

Participants were screened over the telephone using the Structured Clinical Interview for the Diagnostic and Statistical Manual of Mental Disorders, fifth edition (SCID-5; American Psychiatric Association, 2013). All diagnoses were discussed with a psychiatrist specialised in eating disorders (BPN or JT). Inclusion criteria for the eating disorder groups included: adult females, a current diagnosis of BN or BED (DSM-5), no substance abuse, no neurological conditions, and no severe co-morbidity (e.g., schizophrenia). Overweight women and lean comparison women were eligible to take part if they had a BMI over 18.5 and no past or current eating disorder diagnosis. Hampstead NHS Research Ethics Committee granted ethical approval for the study.

### 8.3.3. *Materials*

#### 8.3.3.1. Questionnaires

##### Eating Disorders Examination Questionnaire (EDEQ; Fairburn & Beglin, 1994)

This self-report questionnaire measures eating psychopathology over the last 28 days. The EDEQ has been found to have strong psychometric properties (Mond, Hay, Rodgers, Owen & Beumont, 2004; Luce & Crowther, 1999). The Cronbach's alpha in this study for the EDEQ total = .97.



### Depression Anxiety Stress Scales (DASS-21; Lovibond & Lovibond, 1995)

The DASS-21 measures levels of depression, anxiety and stress over the previous week. The questionnaire has been found to be a reliable and valid measure (Antony, Bieling, Cox, Enns, & Swinson 1998). The Cronbach's alpha for the DASS total = .95.

### Food Cravings Questionnaire-Trait (FCQ-T; Cepeda-Benito, Gleaves, Williams, & Erath, 2000)

This 39-item self-report questionnaire assesses trait food cravings. Based upon a multidimensional conceptualisation of food cravings it has nine subscales. Previous research has found the FCQ-T to have strong test-retest reliability (Cepeda-Benito, Gleaves, Williams, & Erath, 2000) and to be a valid measure in clinical populations with eating disorders (Moreno, Rodríguez, Fernandez, Tamez, & Cepeda-Benito, 2008). The Cronbach's alpha for the FCQ total = .98.

### 8.3.3.2. Computer based tasks

#### Food ratings task

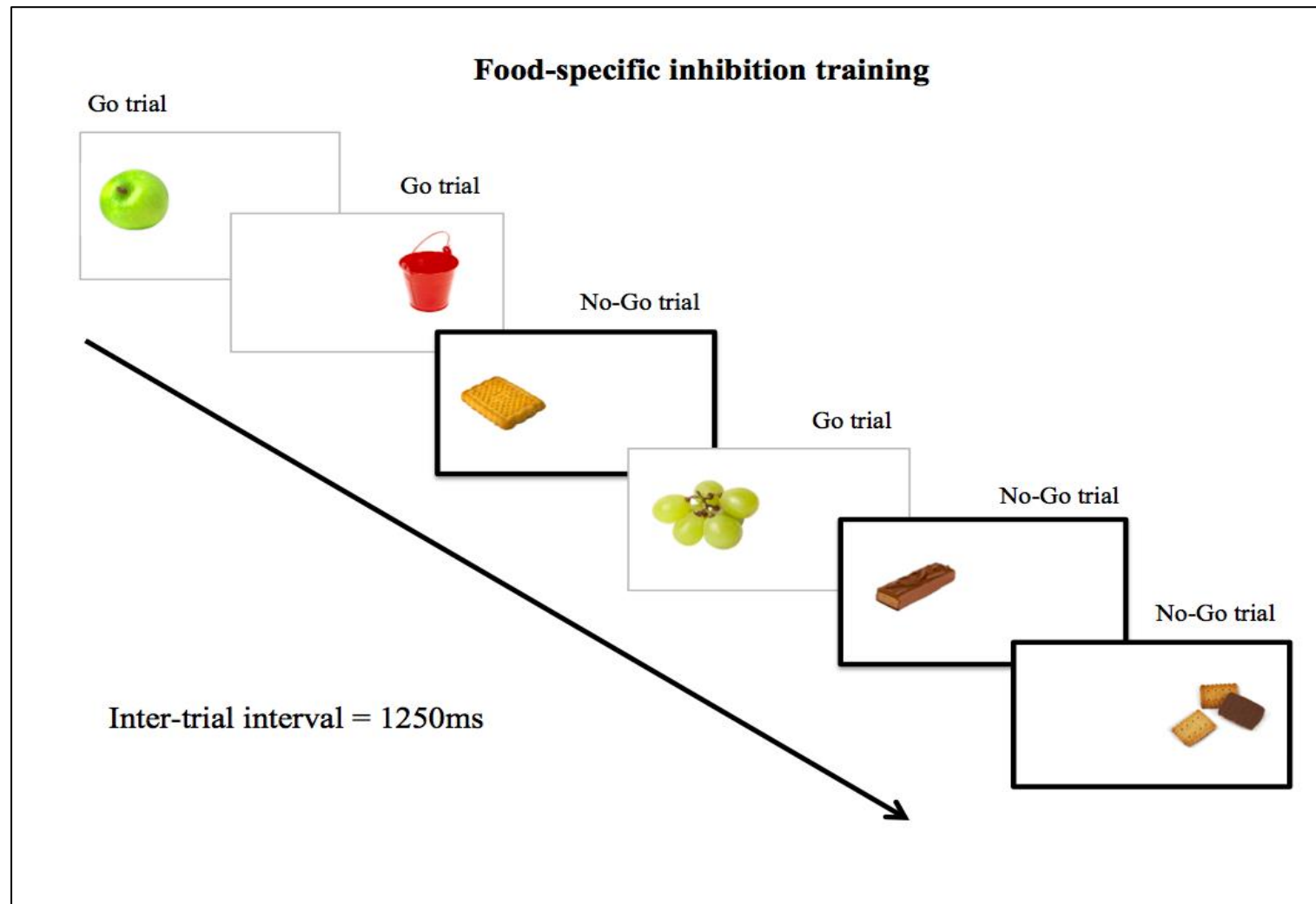
Participants were asked to rate a range of different food images based on how much they 'crave' them (these food items were the same as those in Lawrence et al., 2015a). Responses were measured on 10cm long Visual Analogue Scales (VASs). The food images (18 in total) included nine pictures of high-calorie foods (e.g., 'typical binge foods': chocolate pieces, cake, crisps, biscuits) and nine low-calorie foods (e.g., grapes, rice-cakes, carrot sticks). This food ratings task was a computer-based measure that was programmed using Psychtoolbox (Brainard, 1997) and ran on Matlab (the 64 bit version; Mathworks, 2011). It was adapted from the procedures used by Lawrence et al. (2015a) and Veling, Aarts and Stroebe (2013).

### Go/ no-go training task

This computer-based task was also programmed using Psychtoolbox and ran on Matlab, and followed the procedure of Lawrence et al. (2015a). Participants were instructed that a rectangle will appear in the middle of the computer screen and that within this a picture appears either within the left or right hand side of the rectangle. If the picture appeared on the left hand side of the rectangle, participants were instructed to respond by pressing the letter ‘C’ on the keyboard using the index finger of their left hand. Alternatively if the picture appeared on the right hand side, they had to respond by pressing the letter ‘M’ using the index finger of their right hand. Importantly, participants were instructed to withhold their response and to not press either key if the outline of the rectangle was ‘bold’.

The food-specific inhibition training condition included the same nine pictures of high-calorie foods and nine low-calorie foods that were included in the food ratings task. The high-calorie foods were always paired with the no-go signal (i.e., the line of the rectangle always became bold whenever they were presented onscreen and they were supposed to withhold their response). Please see **figure 1** for an outline of the food go/ no-go training task.

Regarding the general inhibition training condition, the instructions for the task were identical as previously outlined with the only difference being that the 18 food images were replaced with 18 non-food images (i.e., items of furniture, gardening tools and stationery items). The non-food images were taken from an online database (Blechert, Meule, Busch, & Ohla, 2014). For further details regarding the go/ no-go training task procedure please see **supplementary item 1**.



**Figure 1:** An outline of the food-specific inhibition training. Participants have to respond to the go trials by pressing a computer key and withhold their response to the no-go trials (as signalled by the ‘bold’ rectangle around the food item). The high-calorie foods were always no-go trials. In this comparison condition, the no-go signal was paired with the stationery and gardening tool images (i.e., for 100% of these trials).

#### 8.3.3.3. Primary outcome measure: eating behaviour

##### Taste test

The primary objective of the taste test was to measure food consumption following the training tasks. This procedure was based upon the protocol of Adams et al. (2017) and Lawrence et al. (2015a). Participants were presented with portions of chocolate pieces, crisps, grapes and rice cakes (see **supplementary item 2** for portion sizes and further details regarding the taste test procedure). Participants were also presented with a novel food item that was not included in the training tasks. This was a novel exemplar of the high-calorie food categories (i.e., cake/ biscuits) presented in the food-specific inhibition training. In session one, participants were given a portion of flapjack pieces, while in session two they were given chocolate cake bites. This method was used to examine whether any effect of the no-go training would generalize to novel exemplars of high-calorie foods.

#### 8.3.3.4. Secondary outcome measures

##### VASs: anxiety and hunger ratings

VASs anchored by ‘not at all’ and ‘extremely’ (10cms long), were used to measure participants’ levels of anxiety and hunger at baseline and post-training.

##### Food diary: eating disorder symptomatic behaviour

Participants completed an online food diary (using; [www.surveymonkey.net](http://www.surveymonkey.net)). This food diary was based upon those used in previous research (i.e., Bingham et al., 1997; Lawrence et al., 2015a). It involved participants recording their food and drink consumption during the past 24-hours. Participants were also asked to indicate, with an asterisk, any foods that were associated with a sense of ‘loss of control’ while eating and to record any purging episodes.

#### 8.3.3.5. Feedback on the training

To assess the acceptability of the food go/ no-go training task participants were asked for their feedback on it. Participants were asked to rate how much they enjoyed doing the task, the effort involved, how frustrating the task was and how difficult they found it to concentrate (i.e., using a scale ranging from 0 = not at all to 10 = extremely). They were also asked if they would be willing to continue to use the training.

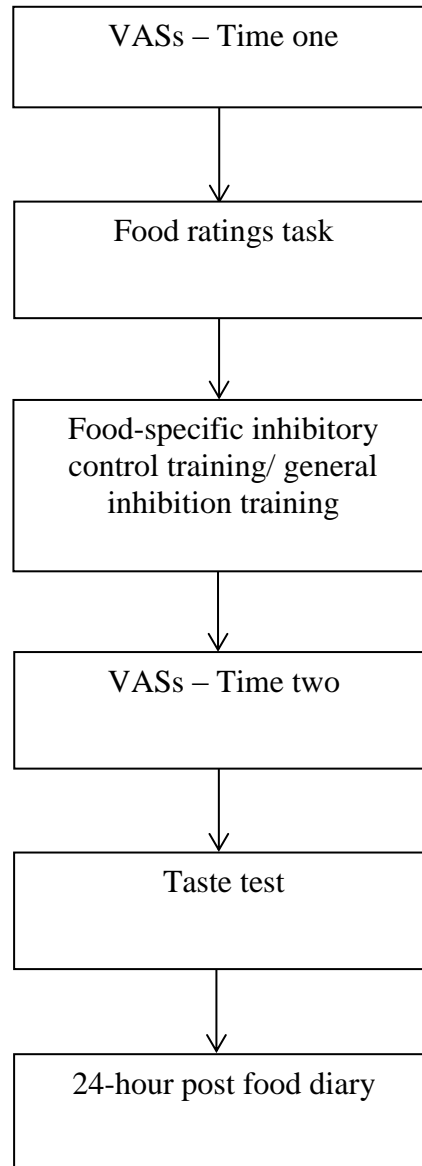
#### *8.3.4. Procedure*

Please see **figure 2** for an overview of the study's design. Demographic and baseline materials were completed through the use of an online survey platform (i.e., [www.surveymonkey.net](http://www.surveymonkey.net)). Participants were instructed to eat something two hours before the start of the first and second session and to then not eat until the time of testing (only drinking water was allowed). The sessions were scheduled between 10am and 7pm with both sessions arranged at a similar time if feasible. They were also asked to complete a food diary at baseline (i.e., 24-hours before the first session).

In both sessions, participants completed the hunger and anxiety VASs and the food ratings task at the start of each session (time point one). After this, participants' completed either the food-specific/ general inhibition training conditions (depending on which they had been randomised to receive in the first session). Following the training, participants completed the VASs again (time point two) and were then taken to a different room within the laboratory for the taste test. In the next session participants completed the other training condition followed by the taste test again. After both sessions participants were asked to record a food diary for the following 24-hours. They were also asked for their feedback on the food go/ no-go training task at the end of the study.

**Procedure:**

Repeated one week apart using a within-subjects design



**Figure 2.** This flow-chart outlines the procedure of the study. Abbreviations: VASs = Visual Analogue Scales (for anxiety and hunger).

### 8.3.5. Data analysis

Participants were excluded from the data analysis if they had incomplete data due to dropping out of the study following session one ( $N = 3$  with BN, 3 lean comparison women, and 1 overweight women) or if they did not follow the training task instructions ( $N = 2$  with BED, 1 overweight and 1 lean women; as indicated by go or no-go error rates over 85%). Following these exclusions, there was a total  $N$  of 86 across all groups, including, 27 women with BN and 17 with BED, alongside 25 lean comparison women and 17 overweight/ obese women.

Craving scores on the food ratings task were then analysed using mixed effects linear models (bootstrapped at 1000 repetitions) using Stata version 14<sup>®</sup> (StataCorp, 2015). Due to technical reasons there were some missing food ratings task data ( $N = 1$  participant with BN, 2 with BED, 3 lean comparison women and 1 overweight women). Separate models were run for the high- and low-calorie foods with the predictors of group (i.e., BN, BED, overweight women or lean comparison women) and training condition (i.e., food-specific or general inhibition training). The Benjamini and Hochberg (1995) correction was used because multiple comparisons were performed. Following this, a  $p$  value threshold of  $< .042$  was used to signify statistical significance for the food cravings data at baseline.

Error rates for go and no-go trials and reaction times were analysed to examine training fidelity. To analyse the taste test data, a mixed effects linear model (bootstrapped at 1000 repetitions) was also carried out to analyse the amount of calories consumed on the taste test between the two training conditions. The food items presented in the taste test were grouped into food types: ‘no-go trained foods’ (i.e., chocolate pieces and crisps), ‘go trained foods’ (i.e., grapes and rice cakes) and ‘novelty exemplar foods’ (flapjack bites or chocolate cake bites). The total amount consumed (measured in kCals) was calculated for each of these three groups. For the analysis, the predictors included in the model were: group, training condition, and food type. The amount of calories consumed was the outcome variable. Due to multiple comparisons, a  $p$  value threshold of  $< .042$  was used when examining group differences in food consumption. Effect sizes were calculated for each of the food

types on the taste test to help aid the development of future studies. Standardised Mean Change (SMC) effect sizes were calculated due to the study's within-subjects design (e.g., Morris & DeShon, 2002). It should be noted that a post-hoc sample size calculation using G\*Power (version 3.1.) showed that the sample size required to have adequate statistical power for the taste test analysis was 827 participants. Therefore, this study was greatly underpowered to find a statistically significant effect on the taste test.

To examine whether VASs for anxiety and hunger differed at baseline and post-training mixed effects linear models were used. The food diaries were analysed to examine levels of eating disorder symptomatic behaviour (i.e., binge-eating/ purging) in the 24-hours post training to test the effectiveness of the training/ whether it caused any adverse effects.

## 8.4. Results

### 8.4.1. Demographic and clinical characteristics

An overview of participants' demographics and clinical characteristics is presented in **table 1**. As to be expected, participants with BN and BED had significantly greater levels of eating disorder psychopathology, depression, anxiety and stress than the comparison women. Eating disorder symptoms (EDEQ total) and depression, anxiety, and stress (DASS-21 total) did not significantly differ between the women with BN and BED. Thirty-three percent (9/27) of the participants with BN and 35% (6/17) of the participants with BED had a co-morbid diagnosis for either an anxiety or major depressive disorder at the time of the study, as assessed by the SCID-5. Also, four participants with BN and one participant with BED were taking medication for mental health problems (i.e., antidepressants). The participants with BED weighed significantly more than the participants with BN, overweight women and lean comparison women.

The participants with BN and BED had significantly greater craving scores (FCQ-T) compared to both the overweight women and lean comparison women for all



subscales, including those related to internal (e.g., negative affect) and external (e.g., resisting food at a buffet) cues. There were no significant differences in participants' levels of anxiety and hunger (as measured by the VASs) at the baseline of both training sessions (all  $p > .05$ ).

	Lean CW(N=25) Mean (SD)	BN (N=27) Mean (SD)	Overweight (N=17) Mean (SD)	BED (N=17) Mean (SD)	Test value Significance
Age	27.2 (6.68)	26.56 (9.32)	29.94 (7.24)	32.18 (6.7)	$F(3,82) = 2.291, p = .084$
BMI	21.66 (1.72)	22.21 (2.58)	29.53(6.68)	35.69 (11.26)	$F(3,82) = 24.39, p < .001$ Lean CW vs. BN, $p = 1$ Lean CW vs. Overweight, $p < .001^*$ Lean CW vs. BED, $p < .001^*$ Overweight vs. BED, $p = .023^*$ BN vs. BED, $p < .001^*$
Illness duration (years)	N/A	8.4 (7)	N/A	13.13(9.58)	$t(40) = -1.820, p = .076$
EDEQ total	.73 (.94)	3.46 (1.17)	1.27 (1.07)	3.96 (.87)	$F(3,82) = 50.83, p < .001$ Lean CW vs. BN, $p < .001^*$ Lean CW vs. Overweight, $p = .576$ Lean CW vs. BED, $p < .001$ Overweight vs BED, $p < .001^*$ BN vs BED, $p = .714$
DASS total	8.88 (7.28)	47.26 (28.56)	14.82 (14.27)	52.82 (21.42)	$F(3, 82) = 26.37, p < .001$ Lean CW vs. BN, $p < .001$ Lean CW vs. Overweight, $p = 1$

					Lean CW vs. BED, $p < .001$ Overweight vs. BED, $p < .001$ BN vs. BED, $p = 1$
FCQ-T: Planning to consume food	6.32 (3.14)	13.56 (3.51)	6.62 (3.5)	14.06 (3.01)	$F(3,81) = 34.65, p < .001$ Lean CW vs. BN, $p < .001^*$ Lean CW vs. Overweight, $p = 1$ Lean CW vs. BED, $p < .001^*$ Overweight vs. BED, $p < .001^*$ BN vs. BED, $p = 1$
FCQ-T: Positive reinforcement	10.52 (4.5)	17.67 (5.95)	9.19 (5)	18.12 (5.8)	$F(3,81) = 15.42, p < .001$ Lean CW vs. BN, $p < .001^*$ Lean CW vs. Overweight, $p = 1$ Lean CW vs. BED, $p < .001^*$ Overweight vs. BED, $p < .001^*$ BN vs. BED, $p = .1$
FCQ-T: Negative reinforcement	5.2 (2.04)	10.81 (4.83)	5.69 (3.09)	9.7 (3.69)	$F(3,81) = 13.79, p < .001$ Lean CW vs. BN, $p < .001^*$ Lean CW vs. Overweight, $p = 1$ Lean CW vs. BED, $p = .001^*$ Overweight vs. BED, $p = .013^*$ BN vs. BED, $p = 1$

FCQ-T: Lack of control	9.8 (4.36)	27.59 (7.28)	9.94 (4.25)	28.71 (4.79)	$F(3,81) = 76.7, p < .001$ Lean CW vs. BN, $p < .001^*$ Lean CW vs. Overweight, $p = 1$ Lean CW vs. BED, $p < .001^*$ Overweight vs. BED, $p < .001^*$ BN vs. BED, $p = 1$
FCQ-T: Thoughts about food	11.72 (3.81)	29.48 (9.43)	10.81 (4.98)	29.94 (8.43)	$F(3,81) = 46.06, p < .001$ Lean CW vs. BN, $p < .001^*$ Lean CW vs. Overweight, $p = 1$ Lean CW vs. BED, $p < .001^*$ Overweight vs. BED, $p < .001^*$ BN vs. BED, $p = 1$
FCQ-T: Hunger	9.88 (3.59)	14.3 (5.02)	9.2 (3.9)	15 (3.45)	$F(3,81) = 10.25, p < .001$ Lean CW vs. BN, $p = .001^*$ Lean CW vs. Overweight, $p = 1$ Lean CW vs. BED, $p = .001^*$ Overweight vs. BED, $p = .001^*$ BN vs. BED, $p = 1$
FCQ-T: Emotional craving	7.84 (3.53)	18.37 (6.03)	8.81 (4.41)	19.94 (4.7)	$F(3,81) = 35.6, p < .001$ Lean CW vs. BN, $p < .001^*$ Lean CW vs. Overweight, $p = 1$ Lean CW vs. BED, $p < .001^*$ Overweight vs. BED, $p < .001^*$

					BN vs. BED, $p = 1$
FCQ-T:	9.76 (4.14)	17.78 (4.12)	11.19 (5.2)	18.29 (4.12)	$F(3,81) = 22.39, p < .001$
Environmental cues trigger eating					Lean CW vs. BN, $p < .001^*$
					Lean CW vs. Overweight, $p = 1$
					Lean CW vs. BED, $p < .001^*$
					Overweight vs. BED, $p < .001^*$
					BN vs. BED, $p = 1$
FCQ-T: Guilt	6.2 (3.23)	14.89 (3.43)	7.44 (4.32)	15.47 (2.76)	$F(3,81) = 43, p < .001$
					Lean CW vs. BN, $p < .001^*$
					Lean CW vs. Overweight, $p = 1$
					Lean CW vs. BED, $p < .001^*$
					Overweight vs. BED, $p < .001^*$
					BN vs. BED, $p = 1$

**Table 1:** This table shows the demographic and clinical characteristics of the participants. Abbreviations: CW = Comparison Women; BMI = Body Mass Index; EDEQ = Eating Disorder Examination Questionnaire; DASS = Depression Anxiety Stress Scale. \*Post hoc test is significant once multiple comparisons are controlled for through the Bonferroni correction.

Craving ratings for both high- and low-calorie foods were taken at the baseline of both sessions:

### High-calorie food cravings

A 4x2 mixed effects linear model (i.e., group x training condition) showed that there was a significant main effect of group on VAS craving ratings for the high-calorie foods ( $X^2(3) = 35.66, p < .001$ ). Pairwise comparisons showed that participants with BN significantly craved these foods ( $M = 46.7, SD = 24.04$ ) more than the lean comparison women ( $M = 39.12, SD = 22.43; Z = 2.31, p = .021$ ). The participants with BED craved them significantly more ( $M = 62.39, SD = 22.5$ ) than the lean comparison women ( $Z = 5.97, p < .001$ ), overweight women ( $M = 46.22, SD = 17.54; Z = 4.04, p < .001$ ) and the participants with BN ( $Z = 4.11, p < .001$ ). The overweight women craved them significantly more than the lean comparison women ( $Z = 2.31, p = .021$ ). There was no significant difference between the overweight women and the participants with BN ( $Z = -.02, p = .99$ ). There was no significant main effect of training condition on VAS ratings for the high-calorie foods or interaction between group and training condition (all  $p > .05$ ). As the craving ratings were completed *before* each training task the lack of effect of training condition is not surprising.

### Low-calorie food cravings

A 4x2 mixed effects linear model (i.e., group x training condition) showed that there was a significant main effect of group on VAS craving ratings for the low-calorie food items ( $X^2(3) = 24.44, p < .001$ ). Subsequent, pairwise comparisons showed that there was no significant difference in cravings for low-calorie foods between the participants with BN ( $M = 32.32, SD = 16.7$ ) and the lean comparison women ( $M = 33.13, SD = 18.18; Z = -.16, p = .872$ ). Participants with BED craved these foods less ( $M = 24.88, SD = 14.42$ ) than the lean comparison women ( $Z = -2.94, p = .003$ ), overweight women ( $M = 38.85, SD = 15.95; Z = -4.92, p < .001$ ) and the participants with BN ( $Z = -2.99, p = .003$ ). The overweight women craved the low-calorie food items more than the participants with BN ( $Z = 2.55, p = .011$ ) and the lean weight comparison women ( $Z = 2.28, p = .022$ ). There was no significant main

effect of training condition or interaction between group and training condition on low-calorie food cravings (all  $p > .05$ ).

#### 8.4.2. Go/ no-go training task

##### Training fidelity

Overall accuracy scores were high (above 85%) for both go and no-go trials across groups and training conditions. There were no significant differences between the participants with BN, BED, overweight women and lean comparison women, in respect to their overall no-go or go error scores between the training conditions (all  $p > .05$ ). Please see **supplementary item 3** for further details regarding training fidelity.

#### 8.4.3. Primary outcome measure

##### Taste test analysis

##### *Group differences in food consumption*

A 4x2x3 mixed effects linear model (i.e., group x training condition x food type) showed that there was a significant main effect of group on the total amount of calories consumed on the taste test ( $X^2(3) = 42.12, p < .001$ )<sup>†</sup>. Pairwise comparisons showed that there was no significant difference in total calories consumed between the participants with BN ( $M = 98.49, SD = 103.52$ ) and lean comparison women ( $M = 112.54, SD = 94.04; Z = -1.62, p = .106$ ). The overweight women ( $M = 149.9, SD = 110.56$ ) and participants with BED ( $M = 150.04, SD = 123.18; Z = -.01, p = .991$ ) did not differ in total calories consumed from each other, whereas, the overweight women consumed significantly more calories in total compared to the lean comparison women ( $Z = 3.57, p < .001$ ), and the participants with BN ( $Z = 4.86, p < .001$ ). The participants with BED also consumed significantly more calories than the lean



comparison women ( $Z = 3.99, p < .001$ ) and the participants with BN ( $Z = 5.26, p < .001$ ).

### *The effect of training condition*

There was no significant main effect of training condition ( $X^2(1) = 1.31, p = .252$ ), interaction between group and training condition ( $X^2(3) = 3.05, p = .383$ ) or between group, training condition and food type ( $X^2(6) = 4.88, p = .559$ ) on the total amount of calories consumed (Please see **table 2.**). Effect sizes were in the expected direction for the women with eating and weight disorders. Participants with BN, BED and overweight/ obese women ate less of ‘no-go trained foods’ (SMC effect sizes small; BN =  $-.22$ ; BED =  $-.24$ ; and overweight women =  $-.04$ ) and ‘novelty exemplar food’ items (SMC effect sizes small; BN =  $-.23$ ; BED =  $-.1$ ; and overweight women =  $-.34$ ) in the food-specific versus general inhibitory control training. They also ate more ‘go trained foods’ in the food-specific training condition relative to the general inhibitory control training (SMC effect size small; BN =  $.16$ ; BED =  $.04$ ; and overweight women =  $.23$ ). The lean comparison women ate more ‘no-go trained foods’ in the food-specific versus the general inhibitory control training (SMC effect size small =  $.18$ ; i.e., the opposite direction to the expected effect).

### *Exploratory correlations*

Food craving ratings for the high calorie foods did not significantly correlate with the difference score for highly palatable (i.e., no-go trained food) food consumption on the taste test between the food-specific and general inhibition training conditions for the women with BN ( $r = .019, p = .925$ ), BED ( $r = -.088, p = .747$ ), overweight women ( $r = -.269, p = .146$ ) or lean comparison women ( $r = .268, p = .217$ ).

Group	Taste test outcome variable	Training condition (kcal consumed)		Effect size: SMC (95% CI)
		Food-specific (active)	General (control)	
		Mean (SD)	Mean (SD)	
Lean comparison women ( <i>N</i> = 25)	No-go trained foods	161.58 (130.58)	140.03 (95.81)	.18 (-.21, .58)
	Go trained foods	62.45 (37.79)	64.89 (37.95)	-.1 (-.49, .29)
	Novelty exemplar food	129.95 (94.25)	116.32 (91.2)	.12 (-.27, .51)
Women with BN ( <i>N</i> = 27)	No-go trained foods	129.89 (129.46)	153.25 (140.48)	-.22 (-.6, .17)
	Go trained foods	55.54 (43.31)	50.78 (36.98)	.16 (-.22, .54)
	Novelty exemplar food	86.07 (66.15)	115.41 (115.61)	-.23 (-.61, .16)
Overweight/ obese women ( <i>N</i> = 17)	No-go trained foods	219.94 (109.01)	225.35 (150.23)	-.04 (-.51, .44)
	Go trained foods	85.4 (32.78)	77.76 (33.36)	.23 (-.25, .71)

	Novelty exemplar food	123.88 (66.18)	167.1 (117.89)	-.34 (-.83, .15)
Women with BED (N = 17)	No-go trained foods	243.2 (111.53)	278.38 (140.59)	-.24 (-.72, .24)
	Go trained foods	46.09 (37)	44.77 (26.77)	.04 (-.44, .51)
	Novelty exemplar food	138.92 (76.86)	148.89 (74.09)	-.1 (-.58, .37)
Women with Binge-eating episodes (BN + BED groups combined) (N = 44)	No-go trained foods	173.67 (133.7)	201.59 (151.94)	-.23 (-.53, .06)
	Go trained foods	51.89 (40.71)	48.45 (33.2)	.11 (-.18, .41)
	Novelty exemplar food	106.49 (74.31)	128.34 (101.96)	-.19 (-.49, .11)

**Table 2:** Shows means and Standard Deviations (SD) for food consumption on the taste test between the food-specific and general inhibitory control training conditions. Effect sizes were calculated for the *no-go* trained, *go* trained and *novelty* high calorie exemplar food items for each group. Standardised mean change effect sizes may be interpreted as small ( $\Rightarrow .2$ ), moderate ( $\Rightarrow .5$ ) and large ( $\Rightarrow .8$ ).

#### 8.4.4. Secondary outcome measures

##### 8.4.4.1. VASs: anxiety and hunger ratings

A 4x2x2 mixed effects linear model (i.e., group x training condition x time point) showed that there was not a significant main effect of condition ( $p = .15$ ) or time point ( $p = .28$ ) on participants' anxiety levels. Regarding hunger, there was not a significant main effect of condition ( $p = .87$ ), although there was a significant main effect for time point ( $X^2(1) = 10.87, p = .001$ ). Pairwise comparisons showed that participants were more hungry post-training (i.e., just before the taste test) than at baseline in both conditions ( $Z = 3.3, p = .001$ ).

##### 8.4.4.2. Food diary: eating disorder symptomatic behaviour

Compared to baseline, fewer participants' experienced binge-eating/ purging episodes after both sessions but there were no significant differences between food specific and general inhibitory control training (all  $p > .05$ ) (please see **supplementary item 4**).

#### 8.4.5. Feedback on the training

The ratings out of 10 were: enjoyment ( $M = 5.8, SD = 1.68$ ), effort ( $M = 5.1, SD = 2.43$ ), frustration ( $M = 3.79, SD = 2.99$ ) and difficulty in concentrating on the task ( $M = 5.11, SD = 2.14$ ). Regarding its acceptability, 92% reported that they would be willing to continue to use the training. Three women with BN didn't return for the second session (i.e., two of these patients had the food-specific inhibition training in session one).

## 8.5. Discussion

This study hypothesised that following the food-specific training participants with BN and BED would reduce their intake of high-calorie foods more than in the general training condition and increase low-calorie food consumption. Also, we examined if overweight women would follow the same behaviour alongside a lean control group. The participants with BN and BED had small non-significant reductions in their consumption of no-go trained, high-calorie foods, post food-specific relative to general inhibition training. There was virtually no change in the consumption of the “healthy” go trained foods for participants with eating disorders. A possible explanation for the non-significant effects of training on food consumption could be that the participants with eating disorders had markers of severe illness (long-illness durations), meaning that an increased dose of training may have been needed to produce greater changes in eating behaviour.

Paradoxically, in the lean comparison women, there was a small increase in the consumption of high-calorie food in the food-specific inhibition training condition. This could possibly be due to the exposure to food images in the active training condition priming lean participants to then consume these foods in the taste test, whereas for the overweight and eating disorder groups the training might have had the opposite effect due to it targeting executive dysfunction hypothesised to be involved in the maintenance of these conditions. Further research is needed to investigate this suggestion.

Food craving ratings did not predict stronger training effects in the present study. Nonetheless, it was interesting to note that at baseline participants with BED craved the high calorie foods more and the low calorie foods less, than the overweight, lean and BN groups. This finding gives support to the theory that people with BED are hyper-responsive to high calorie food cues (e.g., Davis, 2013). Also, the finding that food go/ no-go training was acceptable for the eating disorder groups, corroborates a recent study by Giel, Speer, Schag, Leehr and Zipfel (2017), which found that food-specific inhibition training (using an antisaccade paradigm) was acceptable for women with BED ( $N = 10$  in the training condition). This training approach led to

significant improvements in inhibitory control towards high-calorie foods whilst both the experimental and control condition significantly reduced binge-eating episodes.

A strength of this study is that it is the first to test the effectiveness of food go/ no-go training for women with eating disorders. This is in line with calls for the testing of more precise treatment approaches for these conditions (Turton, Chami, & Treasure, 2017; Voon, 2015). Further, the inclusion of overweight/ obese women and a lean control group allowed for the comparison of food craving ratings and training effects across participant groups. Another strength of this study is that it followed the protocols of Lawrence et al. (2015a) and Veling, van Koningsbruggen, Aarts and Stroebe (2014), by not including any food images in the control condition. This may be considered a more conservative comparison condition than those that include food stimuli or impulsivity priming (e.g., Veling, Aarts, & Stroebe, 2013). In line with this suggestion, Adams et al. (2017) have recently found reduced food consumption on a taste test after food go/ no-go training relative to a go training condition however, no difference was found with an observe condition (i.e., participants watched no-go training but didn't make any responses).

A potential limitation of this study is that it used a within-subjects design whereas all previously published research has used a between-subjects design (i.e., except for Houben, 2011). There may be complications associated with repeated sessions when measuring eating behaviour. For example, people may eat a similar amount of food in each session due to memory of the prior eating episode (e.g., Higgs, 2002; Higgs, Robinson, & Lee, 2012). This was supported by the high correlations in the intake of each food type in session one and two (please **see supplementary item 5** for details regarding these analyses). These analyses also showed evidence for order effects, with the greater intake of the no-go trained, high calorie foods, in the second session relative to the first, perhaps due to participants increased familiarity of the procedure and food items in accordance with the mere exposure effect (Zajonc, 1968). These effects may reduce sensitivity to detect the training effects on food intake.

Another consideration is that the taste test may not be the most ecologically valid way to measure training effects on eating behaviour. For instance, Lawrence et al. (2015a) did not find reduced food intake in a taste test following food-specific versus general

inhibition trained groups (despite observing weight loss and reduced real-world intake as measured by food diaries) – although the taste test was not conducted under laboratory conditions. Therefore, it may be more appropriate for research to assess the effect of food go/ no-go training on other outcomes such as, BMI or eating disorder psychopathology questionnaires. This research would require more prolonged, multi-session training to be able to assess the far transfer of the effects of the training to these outcomes.

#### *8.5.1. Future research directions*

Future studies that include changes to the design of the study are needed to build upon the findings of this study with larger samples as the present study was a proof of concept study and underpowered. It would also be of benefit for future research to use food valuation (VAS) and inhibition tests directly before and after the training to assess baseline and post-training levels of food value and inhibitory control. This would provide additional information about the potential mechanisms of inhibitory control training (Veling et al., 2017). Furthermore, it would be of interest to test the training for people with both eating disorders and impulse control disorders, who have been found to have elevated levels of impulsivity (Fernández-Aranda et al., 2006, 2008).

#### *8.5.2. Clinical implications*

In order to help foster healthy habit formation and larger effects in future research, it may be beneficial to incorporate the three main components of habit formation: frequent repetition, associated context cues and the use of intermittent rewards (Wood & Neal, 2016). Following these principles, future studies could test the use of more intensive go/ no-go training protocols whereby people complete numerous sessions of training in various contexts (e.g., home/work). For example, longer training protocols have been found to reduce daily energy and palatable food intake (Lawrence et al., 2015a; Blackburne, Rodriguez, & Johnstone, 2016), and the liking of high-calorie foods in individuals who are overweight or obese (e.g., Lawrence et al., 2015a). Similar multi-session training protocols may help people with eating disorders to develop more adaptive, and break maladaptive, eating habits.



The self-report index of habit strength (Verplanken, & Orbell, 2003) could be used as a possible mediator/ moderator of training outcome in future research studies that test this hypothesis.

In regards to the incorporation of contextual cues into the training, future studies could tailor the training to the individual by uploading participant's personal 'trigger' foods for binge-eating into the training task (Juarascio et al., 2015). A recent pilot study in obesity has suggested that individualising the training leads to reduced activation in the brain regions associated with reward in overweight and obese people (Stice et al., 2016; Stice, Yokum, Veling, Kemps, & Lawrence, 2017). Therefore, it may also be beneficial for future research in eating disorders to adopt this approach of personalising the training. This might help to increase the precision and effect of food-specific inhibition training on eating disorder symptoms. Another contextual cue for binge-eating is negative affect (e.g., Cardi, Leppanen, & Treasure, 2015; Zeeck, Stelzer, Linster, Joos, & Hartmann, 2011). To target this cue future studies could train emotion regulation or positive mood induction techniques alongside inhibitory control training (e.g., Cardi, Esposito, Clarke, Schifano, & Treasure, 2015; Claes et al., 2012).

In future studies, intermittent rewards could also be given to participants by giving them feedback on their performance on the task (e.g., reaction times, correct signs for successful inhibition, and incorrect signs for no-go errors). This could take the format of a serious game (e.g., Boendermaker, Prins, & Wiers, 2015; Fagundo et al., 2013; Fernández-Aranda et al., 2012). This would have the benefit of enabling the approach to become widely accessible as a mobile application or web-based intervention.

## **8.6. Conclusions**

This study tested the use of food-specific inhibition training for women with BN and BED, as well as in groups of overweight women and lean comparison women. On the go/ no-go training tasks, participants learned to successfully inhibit their response to both food and general stimuli. For the clinical groups, small non-significant effect sizes were found for the reduction of high-calorie food consumption. The next steps for research in this area could involve building upon this study with

larger sample sizes or trialling the use of more sessions and personalised training protocols in real-world contexts for people with eating disorders.

**Footnote:**

† This analysis was repeated examining the effectiveness of the training for participants who only showed signs of successfully stopping on the food-specific and general inhibitory control training task. In order to do this analysis, participant's data was excluded if their go or no-go error rates were above 3SDs from the mean for the control condition and over 2SDs from the mean in the food-specific condition (following the procedure of Lawrence et al., 2015). Furthermore, outliers were removed from the taste test analysis if participants consumed more than 3SDs from the mean for any of the food types. This analysis replicated the findings of the main analysis by showing that there was not a main effect of training condition ( $p = .41$ ) or interaction between group, training condition and food type ( $p = .79$ ) on the taste test. This was also the case when examining the food items presented in the taste test individually (all  $p > .05$ ).

## **8.7. Chapter summary**

This chapter built upon the reviews in chapters six and seven, to test the use of a novel cognitive training approach for people with binge-type eating disorders. This proof of concept study found that a single session of food go/ no-go training produced a small non-significant reduction in the intake of high-calorie foods on a taste test in comparison to a control condition for women with BN and BED. The implication of this work is that further studies that test the effects of the training using more intensive training protocols seem warranted for people with eating disorders. The next chapter will consider other possible future research directions based upon the findings of this thesis as a whole.

## Chapter nine:

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### General discussion

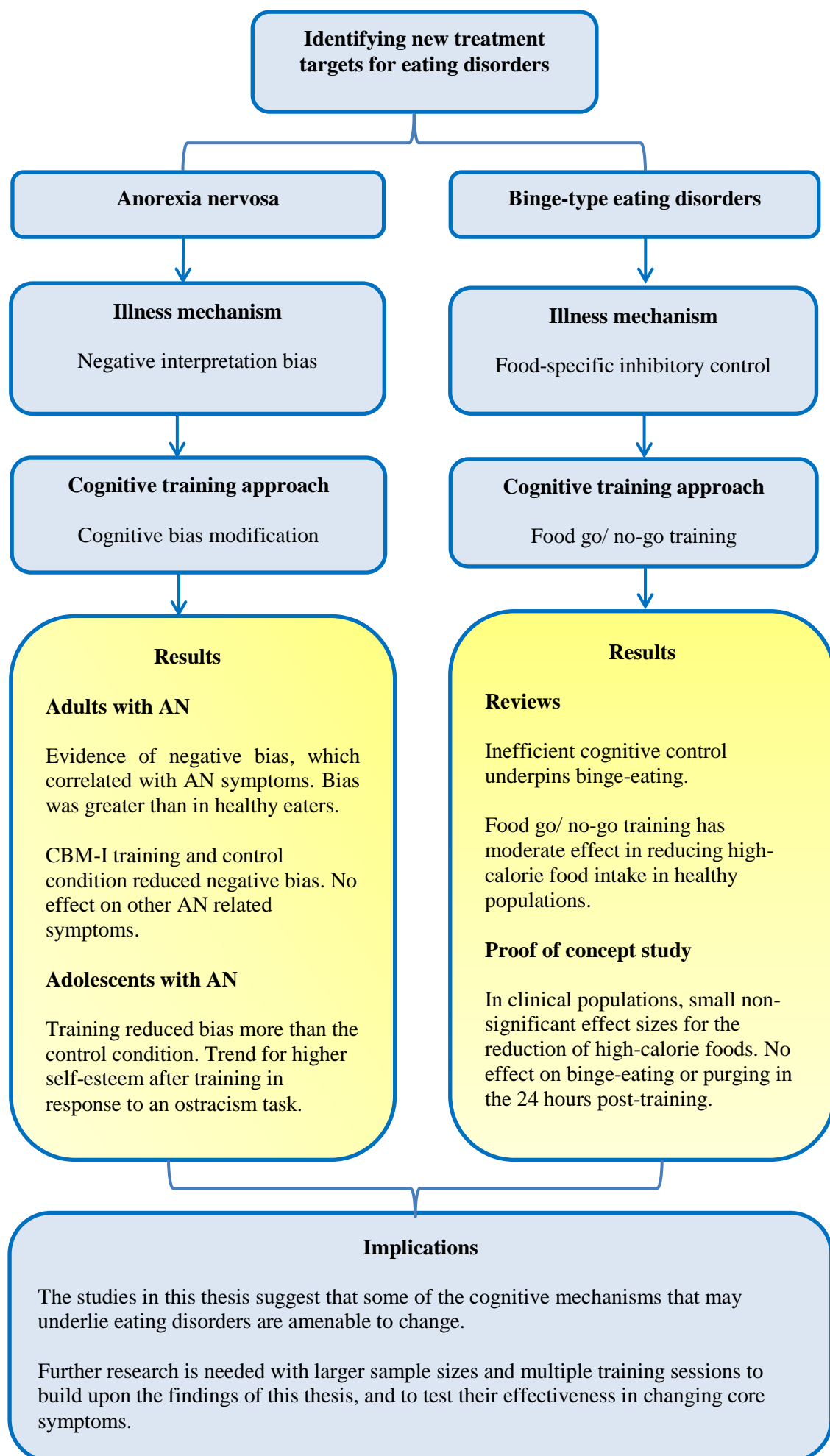
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## 9.1. Chapter aims

This chapter aims to provide an overview of the key findings from the experimental studies and reviews included within this thesis. It will summarise their strengths, limitations, and clinical implications. Furthermore, this chapter will synthesise the findings of this thesis with previous research and suggest avenues for future research.

## 9.2. Overview of thesis aims

This thesis examined in further detail the factors that may underpin eating disorder psychopathology. A cross-sectional study examined whether women with AN have a negative interpretation bias for social stimuli. Furthermore, a narrative review highlighted the mechanisms that might maintain binge-type eating disorders (including inefficient cognitive control). A series of proof of concept studies piloted novel cognitive training approaches targeted at these mechanisms, namely CBM and food-specific inhibitory control. These training approaches were drawn from translational research in other mental illnesses that typically occur co-morbidly with eating disorders, such as anxiety, depression, and substance use disorders. This thesis tested these approaches for people with a range of eating and weight disorders, across different age ranges and treatment settings. Please **see figure 1** for a summary of the key findings of this thesis.



**Figure 1.** This flow-diagram summarises the primary results of this thesis.

### 9.3. Summary of the thesis

The first part to this thesis (**Chapters 3-5**) focused on understanding the role that a negative interpretation bias for social stimuli has in the aetiology of AN. It also tested CBM-I as an approach to modify this bias and examined the effect on core eating disorder symptoms. The aim of this experimental research was to further understand the mechanisms that may underpin socio-cognitive difficulties in AN and to pave the way for the development of new treatment enhancers in future research.

The findings of the empirical studies suggested that both adults and adolescents with AN have negative interpretation bias for social stimuli that depict the risk of rejection. This negative bias correlated with a range of clinical symptoms, including body dissatisfaction, a fear of weight gain, anxiety, and depression. Therefore, a negative interpretation bias for social stimuli that depict the risk of rejection is relevant to the psychopathology of AN. However, causal inferences could not be drawn from these experimental findings.

Consequently, CBM-I was used as an approach to modify negative interpretation bias and examine its impact on other AN related symptoms. These studies showed that for both adults and adolescents CBM-I significantly reduced the number of negative interpretations made after an experimental session of CBM-I training. In adults, no effects on anxiety, eating behaviour or stress (salivary cortisol levels) were after a single session of training. However, in adolescents, there was a trend for participants to have higher levels of self-esteem in response to a Cyberball task in the experimental versus control condition (small to moderate effect size). This suggested that CBM-I training to reduce a negative interpretation bias for social stimuli might help to promote resilience of self-esteem in response to social rejection.

The next part of this thesis (**Chapters 6-8**) highlighted mechanisms that might underlie binge-type eating disorders, and investigated novel approaches to modify these. A narrative review highlighted that binge-eating episodes may begin as impulsive reactions to negative emotional states and adversity. Overtime this symptom may become compulsive due to the process of excessive habit formation and a mechanism that might underlie the impulsive/ compulsive nature of binge-eating is inefficient inhibitory control. Therefore, this thesis included a particular

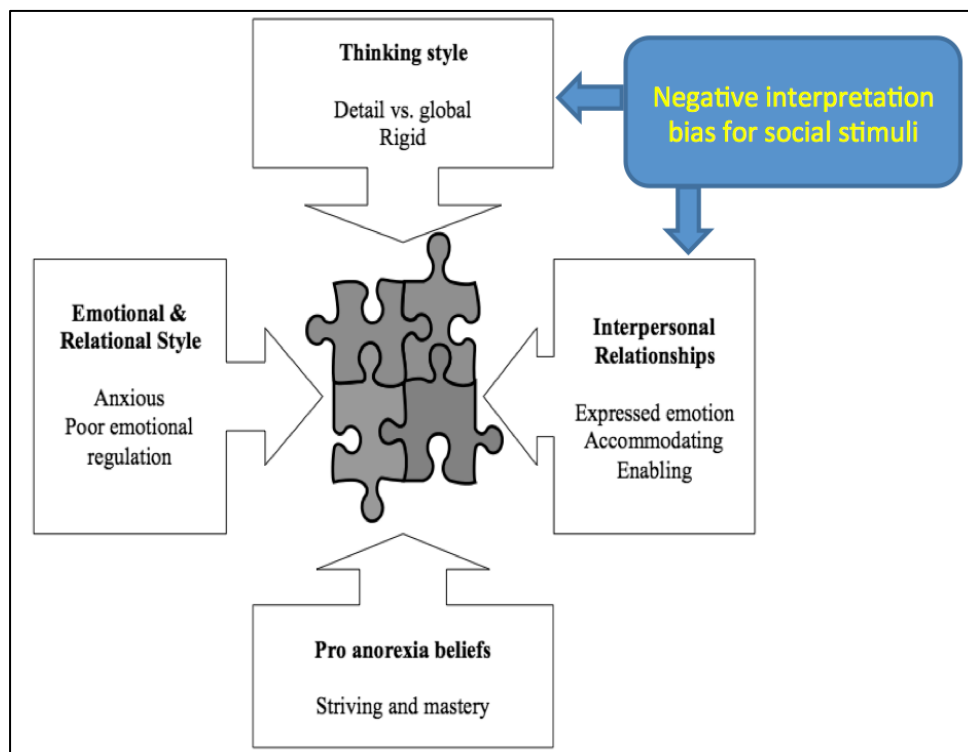
focus on food go/ no-go training as an approach to increase inhibitory control for people that have binge-eating episodes. A systematic review and meta-analysis showed that food-specific inhibitory control training produces a moderate reduction in high-calorie food consumption. Subsequently, this approach was tested for women with BN and BED and found a small non-significant reduction of high-calorie food consumption in an experimental versus control condition for women with BN and BED.

Altogether the findings of this thesis suggested that novel cognitive training approaches could modify cognitive processes thought to cause and maintain eating disorder symptoms (negative interpretation bias for social stimuli and food-specific inhibitory control). However, more intensive training protocols may be needed to produce larger effects on eating behaviour and symptomatology. Furthermore, as the studies included in this thesis were underpowered, to find a statistically significant effect further research should use larger sample sizes.

#### **9.4. Synthesis with theoretical models and previous research**

Chapter three of this thesis found that women with AN have a negative interpretation bias for social stimuli in comparison to healthy eaters. This corroborates the suggestion that a negative interpretation bias is a transdiagnostic phenomenon across several mental illnesses (Hirsch et al., 2016). The large effect size for this negative interpretation bias in AN was consistent with previous research in highly anxious individuals (Huppert et al., 2007), and in people with depression (Rusu, Pincus, & Morley, 2012). Further, the association between a negative interpretation bias for social stimuli that involve the risk of rejection and a fear of weight gain, body dissatisfaction and anxiety/ depression, provides support for the theory that rejection sensitivity has a role in eating disorder psychopathology (Arcelus et al., 2013; Atlas, 2004; Goss, & Gilbert, 2002; Rieger et al., 2010) (Please see **figure 2**).





**Figure 2.** This adaptation of the cognitive-interpersonal model of AN (Treasure, & Schmidt, 2013), shows how a negative interpretation bias for social stimuli might contribute towards the maintenance of symptomatology.

Chapters four and five showed that CBM-I can reduce a negative interpretation bias for social stimuli in adults and adolescents with AN. In adults, this effect was found for both a 100% (experimental condition) and 50% (control condition) dose of training, whereas in adolescents only the 100% dose of training significantly reduced participant's negative interpretation bias for social stimuli. Both studies found moderate to large effects for the reduction in a negative interpretation bias (effect sizes ranged from -.42 to -.66). These effect sizes are slightly smaller than those reported in previous meta-analyses for the effectiveness of CBM in anxiety and depression for reducing a negative interpretation bias (e.g., Hallion, & Ruscio, 2011; found an effect size of .81), perhaps reflecting the complexity of the participant groups included in these studies (e.g., low BMI and long illness durations).

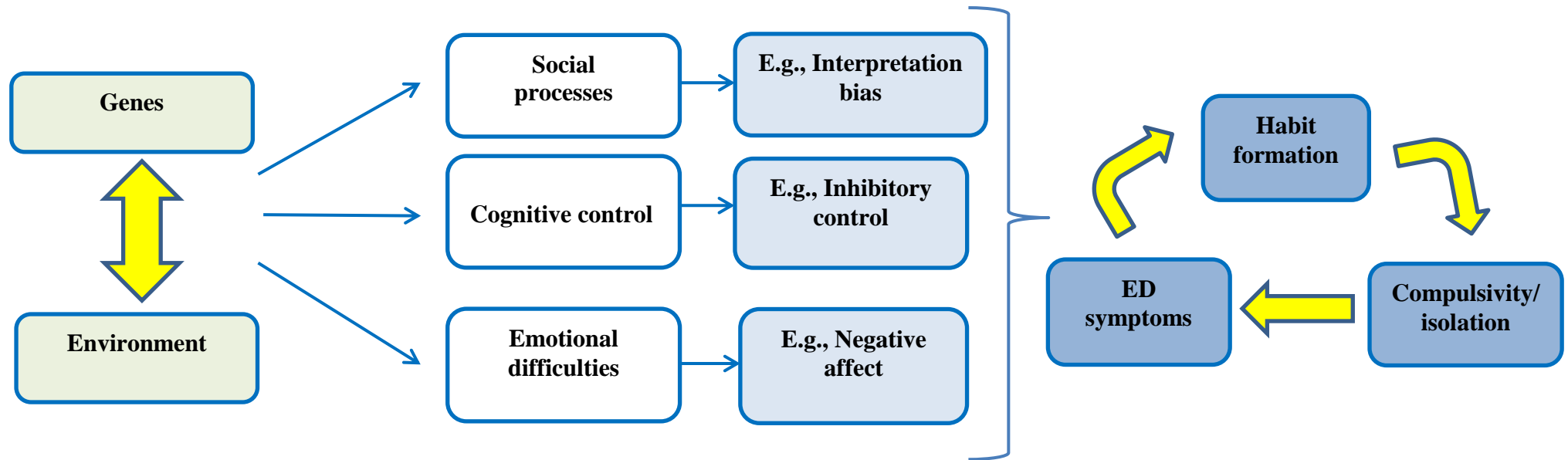
Chapter six of this thesis provided a background literature review to chapters six and seven. Its focus on the mechanisms underpinning binge-type eating disorders

highlighted new targets for treatments, including food-specific inhibitory control. Chapter seven of this thesis included a systematic review and meta-analysis of the literature for three cognitive training approaches (i.e., implementation intentions, food-specific inhibitory control, and attention bias modification). For the implementation intention approach, a small effect size for reducing high-calorie food intake was found (Cohen's  $d = -.31$ ). This finding was consistent with a previous meta-analysis by Adriaanse et al. (2011), which found a similar small effect size (Cohen's  $d = -.29$ ). The review in chapter seven also examined the long-term effectiveness of implementations for reducing high-calorie food intake (Cohen's  $d = -.16$ ) and weight loss (Cohen's  $d = -.04$ ).

Chapter seven was the first review of food-specific inhibitory control training and attention bias modification. Since this chapter was published, two other meta-analyses (Allom, Mullan, & Hagger, 2016; Jones et al., 2016) and one systematic review (Jones, Hardman, Lawrence, & Field, 2017) relating to food-specific inhibition training have been published. These reviews have reported similar moderate effect sizes for the reduction of high-calorie foods (Cohen's  $d$  ranges from  $.47$  to  $.5$ ) to the effect size reported in chapter seven (Cohen's  $d = .58$ ).

Chapter eight included a proof of concept study using a novel food go/ no-go training task for women with BN and BED. The training was found to be acceptable for participants (92%) and produced a small non-significant reduction in high-calorie food consumption on a taste test in comparison to general inhibition training (effect size  $= -.23$ ). The finding that the training was acceptable for participants corroborates the findings of a recent study that also found inhibitory control training (using an antisaccade task) to be acceptable for women with BED (Giel et al., 2017). The small effect size ( $-.23$ ) is lower than those previously reported in the recent meta-analyses relating to the approach (ranging from Cohen's  $d = .47$  to  $.58$ ; Allom, Mullan, & Hagger, 2016; Jones et al., 2016; Turton et al., 2016). This smaller effect size may be due to it being the first study to test food go/ no-go training in a clinical population with eating disorders, whereas previous research has predominately been in healthy/ restrained eaters. Consequently, to produce larger effects in people with eating disorders it may be the case that multiple sessions of training are needed.

Please see **figure 3** for a model that summarises the primary hypotheses tested, and reviewed in this thesis. This model suggests that both genes and environmental factors might increase risk for eating disorders. Cognitive (e.g., inhibitory control, rigid thinking styles), social (e.g., negative interpretation bias), and emotional (e.g., eating in response to negative affect) processes may also underpin eating disorder symptoms. These symptoms become maintained due to excessive habit formation, which, in turn, leads to compulsive behaviours that can isolate the individual. This may further exacerbate eating disorder symptoms. As the studies in this thesis did not find significant effects of modifying a negative interpretation bias or inhibitory control on eating behaviour, more research is needed to clarify whether these processes have a causal role in symptomatology.



**Figure 3.** This model summarises the main hypotheses tested and reviewed in this thesis, which may also be examined in further research.

## **9.5. General strengths of this thesis**

### **9.5.1. The range of clinical populations, age groups and treatment settings**

A primary strength of this thesis is its scope in terms of the range of eating and weight disorders (i.e., AN, BN, BED and overweight/ obese individuals), age groups (i.e., young people and adults), and treatment settings (i.e., inpatient, outpatient and community women) included. This led to important considerations in terms of the design of the studies. For instance, for studies one, two and three the sentence completion task and CBM-I training stimuli were specifically tailored to a central characteristic of AN (i.e., rejection sensitivity), and to be age-appropriate (e.g., the scenarios for the young people related to school, extracurricular activities and social networking whereas for adults they included topics such as work and romantic relationships). This helped to ensure that the scenarios included were both relevant and realistic for the participant groups, and is in line with recent calls for cognitive bias modification research to adapt a more systematic and theoretically grounded approach to the development of training stimuli (Hughes, Gordon, Chalder, Hirsch, & Moss-Morris, 2016).

### **9.5.2. Translational approach**

Another strength of this thesis is the underlying principle of translating findings from basic science (preclinical research) to clinical populations. For example, review one summarised, and critically appraised, new knowledge relating to the mechanisms that might underlie binge-type eating disorders. This included the latest findings from animal based models of binge eating, and helped to identify a range of potential mechanism that could be targeted by novel techniques. Review two then systematically reviewed approaches that have been tested in healthy populations to develop healthier eating habits and performed a meta-analysis of the available data. This suggested that approaches such as food-specific inhibitory control training and attention bias modification are useful in reducing the consumption of highly palatable

(typical binge) foods. Consequently, study four translated the findings from reviews one and two into the piloting of the food-specific inhibitory control training approach for women with BN and BED. Therefore, this translational approach follows the steps outlined in guidelines for developing evidence-based treatments (e.g., Akobeng, 2005).

#### 9.5.3. Transdiagnostic approach

This thesis draws upon the use of cognitive training approaches from other mental illnesses that often occur comorbidity with eating disorders. For example, CBM-I training approaches have been tested more extensively for people with emotional disorders (Blackwell, & Holmes, 2010; Hayes et al. 2010; Williams et al., 2013), whilst inhibitory control training is also being tested for people with substance use disorders (Jones et al., 2014). This transdiagnostic approach seems warranted due to the evidence of shared risk and maintenance factors across diagnoses, such as negative interpretation biases and inefficient cognitive control (e.g., Hirsch et al., 2016; Robbins et al., 2012). Therefore, this thesis incorporated elements of the RDoC initiative to increase understanding of the constructs underpinning eating disorder psychopathology, and aid treatment development. This ethos could be extended in further research by examining whether a negative interpretation bias of social stimuli (that involve the risk of rejection) is also pertinent to the psychopathology of binge-type eating disorders, and whether approaches such as CBM-I training may be of benefit for peoples with these mental health conditions.

#### 9.5.4. Experimental designs

Jansen (2016) recently commented on the importance of experimental psychopathology studies for the field of eating disorders stating that, “the lack of understanding mechanisms that cause, maintain and change eating disorders is currently the biggest problem facing the science of eating disorders” (p. 2), and that experimental studies could help to obtain this knowledge. Consequently, a strength of this thesis is the use experimental paradigms to try and modify aspects of eating

disorder psychopathology, such as cognitive biases, dietary restriction, and binge-eating episodes.

#### 9.5.5. Multi-modal outcome measures

A general strength of this thesis is that it utilised a range of outcome measures to assess the feasibility and effectiveness of the cognitive training approaches. This included computer based tasks (e.g., sentence completion task), self-report measures (e.g., VASs), biological measures (e.g., salivary cortisol levels), and measures of eating behaviour in the laboratory (e.g., the taste test) and ‘real-world’ (e.g., food diaries). This array of outcome measures meant that studies two, three, and four examined both the ‘near’ and ‘far’ transfer effects of the different cognitive training approaches. Previous research has suggested that these outcome measures are sensitive to detect changes following single dose interventions (e.g., Burgess et al., 2016; Cardi, Esposito, Clarke, Schifano, & Treasure, 2015; Leppanen et al., 2017). Hence, they may have been amenable to change in the single session cognitive training studies included within this thesis.

### **9.6. General limitations of this thesis**

#### 9.6.1. Methodological considerations

The findings of this thesis should be interpreted in consideration of several methodological factors. For example, the laboratory setting may have affected participants’ eating behaviour. In line with this suggestion, research has suggested that women consume less food on a test meal when they are aware that their food intake is being monitored (e.g., Robinson, Kersbergen, Brunstrom, & Field, 2014; Robinson, Proctor, Oldham, & Masic, 2016). Efforts were made to reduce the potential for this bias by using the cover story of a taste test, however, participants may have still restrained their eating to a greater extent than in a more naturalistic setting. Furthermore, although studies two and three suggested that it is possible to modify a negative interpretation bias for social stimuli, it is currently unknown how this learning translates to social situations outside of the laboratory when they actually



occur. Future research could potentially examine this by asking participants to monitor and record their thoughts when they experience ambiguous social scenarios that involve the risk of rejection in everyday life.

Another methodological consideration that may have impacted upon the outcome of the experimental studies is the use of repeated measures designs. For instance, in study four, there was evidence for order effects in food consumption on the taste test. This may have decreased the sensitivity of the experimental studies to find significant training effects on far transfer outcomes, such as eating behaviour. Therefore, it may be beneficial for future research to use between subjects designs or to make adaptations to the studies design to reduce the change for order effects (e.g., having a longer period of time between the two testing sessions to reduce the change of memory effects).

#### 9.6.2. Demand characteristics

Previous research into cognitive training approaches has used more elaborate cover stories for their studies in comparison to the ones included within this thesis. For instance, Lawrence et al. (2015) informed participants that their study into food-specific inhibition training was investigating the effects of reward and motivation on computer tasks assessing attention and reaction times. They were given the food as a form of refreshment whilst completing a set of personality questionnaires. Whereas, in this thesis, study four informed participants that it was examining the use of a computerised games for eating disorders, and that participants would complete a taste test. This information may have meant that the aims of the study were slightly more transparent than previous research and, therefore, possibly more subject to demand characteristics. However, steps were taken to reduce the potential for this bias (e.g., participants were not informed that there was an experimental and control version of the training). The decision to not use more elaborate cover stories in this thesis was partly an ethical decision. This is because people with eating disorders often report feeling coerced (Treasure et al., 2011). Therefore, it may not be considered appropriate to entirely deceive them to the real aims of a study.

### 9.6.3. Sample sizes

The studies included within this thesis are underpowered due to their proof of concept designs. Nevertheless, the aim of this work was to explore the effects of a single session of training to analyse whether further research with these training approaches is warranted in eating disorders. Particularly, given the costs, resources, and time required performing larger trials. Furthermore, the use of single-session designs followed the need for more experimental psychopathology studies within the field of eating disorders (Jansen, 2016).

## **9.7. Future directions**

### 9.7.1. Baseline assessments

This thesis included a baseline assessment of a negative interpretation bias in women with AN relative to a healthy population in study one. However, study three did not include a healthy comparison group of young people with AN. This means that although young people with AN report heightened levels of rejection sensitivity (Patel, Tchanturia, & Harrison, 2016), and made more negative interpretations than benign on the sentence completion task at baseline in study three, it is currently unknown how their interpretational style directly compares to young people without an eating disorder. Therefore, examining whether young people with AN have a greater negative interpretation bias for social stimuli than healthy comparison groups is an important question for future research.

Another point of consideration is that study four did not include a baseline assessment of participant's levels of food-specific and general inhibitory control. Berner, Winter, Matheson and Benson (2017) have recently stated that further research using neuroimaging is needed to compare how people with binge eating perform on food-specific and general tasks of cognitive control (e.g., go/ no-go tasks) and reward processing (e.g., progressive ratio tasks). This may use methods such as electroencephalography to monitor participant's performances on the task at baseline, and it could also be employed as potential outcome measure post-training. Furthermore, future research could also conduct an updated meta-analytic review of

food-specific inhibitory control difficulties in eating disorders, given that more research has been published since the review by Wu et al. (2013),

#### 9.7.2. Mediators, moderators and mechanisms

Research could examine potential mediators and moderators for the cognitive training approaches explored within this thesis. For instance, research in healthy populations has suggested that levels of dietary restriction (Houben, & Jansen, 2011; Lawrence et al., 2015; Veling et al., 2011), and inhibitory control (Houben, 2011), moderate the effect of food-specific inhibition training. Therefore, future endeavours could seek to examine the effect of individual differences on training effects for people with eating disorders.

Another factor that has been proposed to impact the outcome of cognitive training approaches is a person's genotype. Fox, Zougkou, Ridgewell and Garner (2011) found that healthy adults with a low expression of the serotonin transporter gene 5HTTLPR were more sensitive to the effects of attention bias modification than participants with a high expression form of the gene, suggesting that this genotype may be a 'plasticity gene'. Future studies may examine whether a participant's genotype influences their response to other cognitive training approaches, such as CBM-I training and food-specific inhibition training.

More work is also needed to understand the mechanisms underlying the cognitive training approaches. For example, in the food-specific inhibition training literature there is currently discussion regarding the mechanisms that may underlie the approach (for a recent review please see: Veling et al., 2017). To help answer this question, research is needed with a range of 'near transfer' dependent outcome variables, such as inhibitory control levels, food 'liking', and 'wanting'. Mediation analysis could then be conducted to examine whether these mechanisms are (partly) responsible for training effects.

### 9.7.3. Replication studies

A current topic of debate within the literature is whether there is a replication crisis within the field of psychology (e.g., Lindsay, 2015; Maxwell, Lau, & Howard, 2015; Pashler, & Harris, 2012; Stroebe, & Strack, 2014). This was exemplified by research from the Open Science Collaboration (2015) that aimed to replicate the findings of 100 psychology experiments. Of note, this study found that of only 35% of the replication studies conducted found significant results ( $p < .05$ ), as opposed to 97% of the original experiments. Furthermore, the mean effect sizes were less than half in the replication studies (.403 in the original experiments versus .197 in the replication studies). This led the authors of the collaboration to conclude that, “innovation points out paths that are possible; replication points out paths that are likely” (p. 943). Replication studies are needed to confirm the findings of this thesis particularly, given that the experimental studies were pilot studies, and their respective hypotheses have not been tested previously.

Potential factors that can contribute to a failure to replicate the findings of a study are thought to include insufficient power, the dropping of variables, and practices such as “p-hacking” (i.e., conducting multiple statistical tests on a data set until a significant result is found without a priori hypotheses; Head, Holman, Lanfear, Kahn, & Jennions, 2015; Lindsay, 2015). In order to help prevent these biases from effecting research into cognitive training approaches, Veling et al. (2017) have called for researchers to pre-register studies and to have clearly defined primary outcomes. This is a vital next step for research into eating disorders that has already been put into practice for other cognitive training paradigms such as approach bias modification through the publishing of study protocols (e.g., Brockmeyer, Schmidt, & Friederich, 2016). Another approach to help reduce biases is for both the investigators and participants to be fully blinded (i.e., double blind designs) throughout a trial and data analysis stages (Day & Altman, 2000; Hróbjartsson & Boutron, 2011).

#### 9.7.4. Recommendations for future experimental studies

The experimental studies within this thesis were conducted in parallel therefore; it was not possible to adapt the design of the later reported studies in the light of experimental experience (e.g., modifying the design of the CBM-I study with adolescents following the findings of the study with adults). However, going forward these considerations may be taken into account when designing future experimental studies.

For instance, the empirical studies in this thesis used a graduated dose-response design when comparing an experimental version of cognitive training to a ‘control’ condition (e.g., a 100% dose of CBM-I training was compared against a 50% dose of the training). For adults both doses of CBM-I training led to a significant reduction in a negative interpretation bias for social stimuli meaning that significant differences between conditions in eating disorder symptoms were then not found post-training. Given this it may be beneficial to use a ‘maximum difference design’ between experimental and control conditions in future research to investigate if this produces larger training effects on eating disorder symptoms. This could involve comparing a 100% dose of CBM-I training to an entirely ‘neutral’ training condition that does not involve either a negative or benign ending to ambiguous scenarios (as employed by Krahé et al., 2016).

In future research it may also be beneficial to personalise the training stimuli to examine if this produces larger training effects. For example, in **chapter five** the ambiguous social scenarios used in the CBM-I training task included a selection of stimuli that were created by adolescents with AN during a focus group at the inpatient hospital (i.e., people not included in the study). This service-user involvement may be a potential reason as to why this study found larger training effects than the CBM-I training study in adults whereby the scenarios were created by researchers and therefore, potentially could have been less pertinent to the participants. Similarly, in the food go/ no-go training task, the future studies could test the use of personalised training stimuli (i.e., images of participants own typical binge foods) to examine if this produces larger training effects than the use of ‘generic’ binge food pictures in **Chapter eight**.

It may also have been beneficial to use outcome measures that were more closely aligned to the primary aim of the respective cognitive training approaches. For example, the test meal procedure used in **chapter four** may have been considered quite an ambitious outcome measure to see change on following only a single session of training. Future research could still use this test meal procedure however, it may be beneficial to adapt it by also asking participants whether they feared negative evaluation or rejection from the experimenter as they re-entered the room after the allocated 5-minutes. Or it could also be possible to assess eating following the training in a more social environment such as a café or restaurant to examine fears of social rejection following CBM-I training. This outcome would then be more closely in line with the primary aim of CBM-I training for social scenarios.

Finally, another consideration across the experimental studies was that participants were recruited with long eating disorder illness histories, which may partly explain why a single session of cognitive training did not produce larger effects on symptomatology. This would be in line with the staging model of eating disorders, which predicts that eating disorder symptoms become more embedded and harder to change over time due to neuroadaptation (Treasure et al., 2015). As a result, it may be beneficial for future experimental research to test the effects of cognitive training approaches either in high-risk healthy populations or for people with a recent eating disorder onset whereby symptoms may be more susceptible to change.

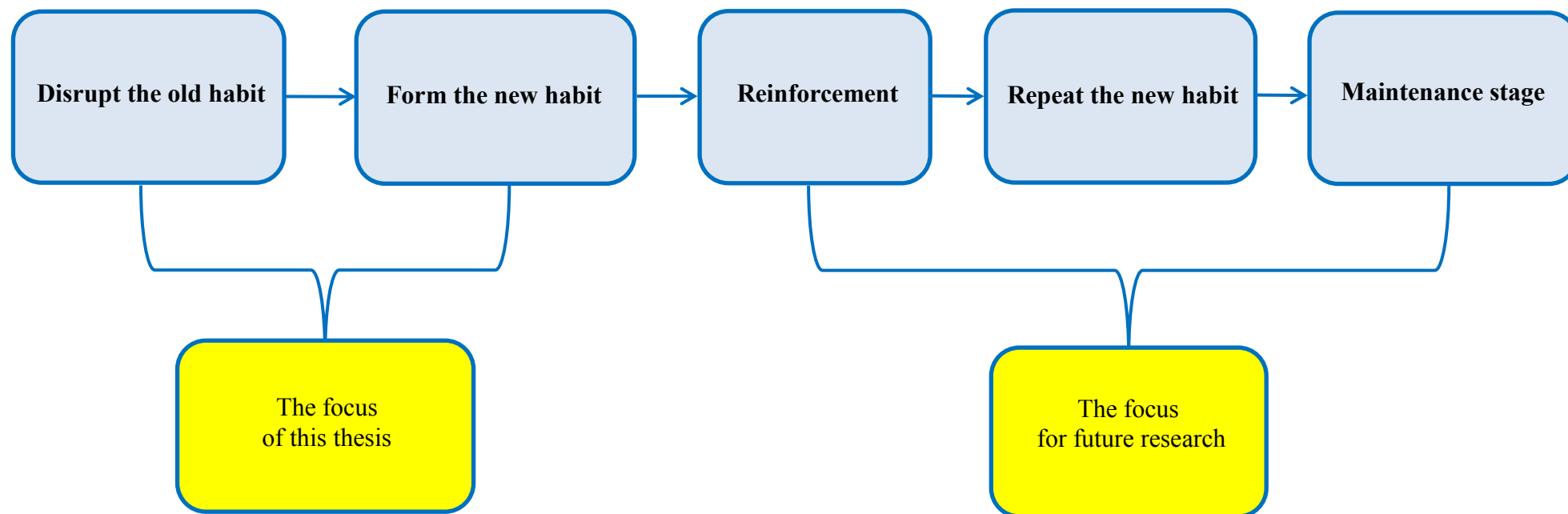
#### 9.7.4. Multi-session studies

This thesis focused on modifying some of the mechanisms that might maintain eating disorder psychopathology. The aim was to break maladaptive eating disorder habits, such as negatively interpreting social stimuli or losing control over “typical binge foods”, and to aid the development of more adaptive habits (i.e., having a benign interpretational style, or the increased consumption of low calorie foods for binge-type eating disorders). This may be considered the first stage in the formation of new habits (please see **figure 4** for an overview of the stages of habit formation). Maintaining this new habit is likely to require both reinforcement and repetition (Wood & Neal, 2016; Wood & Rünger, 2016). Hence, the focus of future research

may be to test the use of multiple sessions of CBM-I training or food-specific inhibitory control training for people with eating disorders.

An important consideration for future research using multiple training sessions of food go/ no-go training for people with eating disorders is to monitor the effect of the training on weight, particularly for people with BN. This is because previous research has shown that food-specific inhibitory control training can lead to weight loss in overweight and obese individuals (Lawrence et al., 2015; Stice et al., 2016). Given that there are high-rates of diagnostic cross-over between BN and AN, weight-loss could be a potential adverse outcome of the training for people with BN. Therefore, weight needs to be carefully monitored in future multiple-session training studies.





**Figure 4.** This diagram is based upon the stages of habit formation (e.g., Lally, & Gardner, 2013; Wood & Rünger, 2016). It highlights the focus of this thesis (modifying eating disorder habits), and the potential direction for future research (examining how new habits can be reinforced and maintained over time).

#### 9.7.5. Cognitive training as an adjunct treatment enhancer

If the cognitive training approaches investigated within this thesis are to be used in the treatment of eating disorders, it is probable that they would be most effective in conjunction with other psychological and pharmacological treatments. This is because cognitive training approaches may be considered as precise treatments to target specific symptoms rather than as holistic treatment approaches. For example, Capron, Norr, Allan and Schmidt (2017) have found that psychoeducation plus CBM-I training is significantly more effective than psychoeducation alone in reducing anxiety sensitivity in highly anxious individuals with a large effect size (Cohen's  $d = .99$ ). These additive effects of CBM-I training were maintained at the one-month follow-up. Future research may examine whether similar additive effects of cognitive training are found for people with eating disorders. For instance, randomised controlled trials could investigate whether cognitive training approaches, such as CBM-I or food-specific inhibitory control training, are of benefit in adjunct to CBT for people with eating disorders.

#### 9.7.6. Other cognitive processes, training approaches and populations

In the fields of anxiety disorders (Hirsch, Clark, & Mathews, 2006) and depression (Everaert, Koster, & Derakshan, 2012) it has been hypothesised that several cognitive biases may combine together to cause and maintain these illnesses. This includes a range of information processing biases relating to interpretation, attention, mental imagery, cognitive control and memory, which may interplay with one another rather than act in isolation (Hirsch, Clark, & Matthews, 2006; Everaert, Koster, & Derakshan, 2012).

Further research may seek to examine whether several cognitive biases combine together to maintain the psychopathology of eating disorders. This may involve the testing of interventions that involve several cognitive training approaches. For instance, Cardi et al. (2015) tested the effectiveness of cognitive bias modification for both interpretation and attention biases in adults with AN. It would be interesting to test this approach for other populations such as young people with AN.

Pilot work for this thesis using visual images of the ambiguous social scenarios in the CBM-I training suggested that participants with AN began to focus on body-related social comparisons with the individuals in the image, rather than focusing on the nature of the social scenario. One possibility in future research could be to use positive mental imagery related to the scenarios instead of visual images. In support of this idea, Farrar, Stopa and Turner (2015) found that inducing a positive self-image produced an increase in positive affect for people with high levels of body dissatisfaction. Therefore, future CBM-I studies could incorporate mental imagery techniques into the training, as seen in emotional disorders (e.g., Holmes, Lang, & Shah, 2009).

This thesis only recruited females with eating disorders, meaning that it is currently unknown how effective the cognitive training approaches are for males with eating disorders in modifying cognitive maintenance factors. Menne-Lothmann et al. (2014) found that CBM-I training is more effective for women than men (mixed sample of healthy individuals and people with emotional disorders), in regards to both cognitive and mood effects. Future research may also examine whether cognitive training approaches have different effects for males and females with eating disorders.

#### 9.7.7. Utilising new technology

Virtual Reality (VR) is a new technology that may be useful as a computerised treatment approach for mental illnesses (Freeman, Reeve, Robinson, & Ehlers, 2017). So far, it has been tested for a range of mental health conditions, such as social anxiety (Anderson et al., 2013), panic disorder (Pitti et al., 2015), and post-traumatic stress disorder (Rothbaum et al., 2014). The use of this new technology is an area of rapid growth with a recent systematic review by Valmaggia et al. (2016) highlighting that between 2012-2015, twenty-four controlled trials have been published testing VR for populations with mental health conditions. This review showed that promising findings have been reported, albeit studies have typically had small sample sizes.

Using VR, Mountford, Tchanturia and Valmaggia (2016) simulated a social scenario (a London bus journey) and found that dieters (with body image concerns) had elevated levels of social evaluative concerns from other passengers on the bus relative to non-dieters. Future research could use VR technology to gradually expose people with eating disorders to ambiguous social scenarios that involve the risk for social rejection. This immersive training approach may be useful for people with eating disorders.

## 9.8. Theoretical and clinical implications

The findings of this thesis may have important implications in regards to both theory and clinical practice. As outlined in **chapter one** of this thesis, several theoretical models have been proposed over recent decades to explain the factors that may cause and maintain eating disorder symptoms (e.g., Fairburn, Cooper, & Shafran, 2003; Southgate, Tchanturia, & Treasure, 2005; Treasure, & Schmidt, 2013). However, as stated in the introduction to this thesis, a potential limitation of these models is that they do not describe in great detail the specific psychological mechanism that may underpin the factors that may cause and maintain eating disorders. The result in **chapter three** that a negative interpretation bias for social stimuli is associated with AN symptomatology provides support to the theory that interpersonal difficulties are involved in the aetiology of eating disorders (e.g., Rieger et al., 2010). Consequently, this cognitive mechanism could be added to existing socio-cognitive theories of eating disorders as a factor that underpins interpersonal difficulties and eating disorder symptoms.

Treatment approaches that focus on improving interpersonal relationships such as interpersonal psychotherapy for eating disorders, CBT-ED, and MANTRA might further benefit people with eating disorders by focusing on helping them to develop a more benign interpretational style. The findings of **chapter 5** in this thesis suggested that this might also have the potential to impact positively on young peoples level of self-esteem. This could be done therapeutically by asking people to monitor and record their thoughts when they experience ambiguous social scenarios that involve

the risk of rejection and to then reflect in therapy on whether they tend to make negative or benign interpretations of these situations and what alternate and less threatening resolutions there could be. For example, anecdotally many participants in **chapters three, four and five** reported that when completing the sentence completion task they realised for the first time that they had such a strong and habitual negative bias, and that they found it helpful to listen to benign interpretations (or ‘alternate viewpoints’) as they had not even thought of these as possible resolutions previously. Given this CBM-I could also then be used as a cognitive training tool to supplement the work in therapy as opposed to a ‘stand-alone’ approach.

In regards to food-specific inhibitory control the findings of this thesis provide some support to the theory that inefficient inhibitory control is a mechanism that underlies binge-eating episodes (Robbins et al., 2012). If food-specific inhibition training is to be used therapeutically, it may be beneficial to use it alongside or as part of new treatment approaches that are specially targeted at reducing impulsivity and improving inhibitory control as seen with promising effects in a new intervention called ImpulsE (Preuss, Pinnow, Schicker, & Legenbauer, 2017).

ImpulsE is a novel group therapy programme for individuals that are either overweight and/ or that have binge-eating episodes and it involves a mixture of psychoeducation, emotion regulation skills training, problem-solving and inhibition training (food stop-signal training). A pilot RCT of this approach for sixty-nine individuals with obesity and/or binge-eating episodes found that at 3-months follow up this approach was significantly more effective in reducing eating disorder symptoms (as measured by the EDEQ) and greater weight loss than those that were allocated to receive CBT. Given that this RCT tested the effectiveness of stop-signal training it may be beneficial for future clinical trials to test food go/ no-go training given that the meta-analysis in **chapter seven** suggested that this approach produces larger effects on eating behaviour.

An important issue for the field of eating disorders to address is ‘the treatment gap’ (Kazdin, Fitzsimmons-Craft & Wilfey, 2016). Namely, how to help the large number of people with eating disorders that currently receive no support or treatment (i.e., approximately 80% of individuals with eating disorders). As outlined in the

introduction to this thesis, this may be particularly the case for people with BED. One potential solution is through the use of innovative internet platforms or mobile applications that may be acceptable to people with eating disorders, cost-effective and widely disseminated (e.g., Ambwani, Cardi, & Treasure, 2014; Fairburn & Murphy, 2015; Fairburn & Patel, 2017; Fairburn, & Rothwell, 2015). Another advantage of Internet platforms or mobile application based cognitive training is that people that are on waiting lists for treatment could also access them before therapy. Moreover, it may be speculated that approaches such as CBM-I that focus on how people interpret interpersonal relationships could possibly then influence engagement and the ability to form a positive therapeutic relationship within treatment positively. However, this hypothesis needs testing.

Food-specific inhibition training has been shown to have promising results when delivered via the internet (Lawrence et al., 2015), and as a mobile application (Blackburne, Rodriquez, & Johnstone, 2016), for individuals that are overweight or obese. A clinical trial is currently beginning testing the use of online food-specific inhibition training for women with BN and BED (Chami, Cardi, McLoughlin, & Treasure, 2017). This is a multisession randomised controlled trial with binge eating frequency as the primary outcome and secondary outcomes including BMI, levels of inhibitory control and food consumption on the taste test. This study involves both food-specific inhibition training and the use of implementation intentions, and is an important next step in developing and testing this cognitive training approach for people with eating disorders. To date, CBM-I training has not been tested as an internet-based or mobile-based application for people with AN. Ultimately, this research may lead to the development of new techniques to augment the effectiveness of existing treatments and that can be accessible to a wider group of people (Forman et al., in press).

## **9.9. Conclusion**

This thesis had two primary aims, to build an accurate profile of the cognitive mechanisms underpinning eating disorder psychopathology, and to test training approaches that could help modify these processes. A cross-sectional study suggested

that a negative interpretation bias for social stimuli is a mechanism associated with the psychopathology of AN, while a narrative review highlighted that inefficient cognitive control might underpin binge-type eating disorders. Proof of concept studies tested the effect of CBM and food go/ no-go training in modifying these processes. The cognitive training approaches were acceptable for participants, and produced significant small to moderate effects in changing the cognitive maintenance factor (near transfer outcomes). However, there were small non-significant effects on far transfer outcomes, such as eating behaviour. Therefore, it may be beneficial, for future research to test the effect of multiple sessions of training on core symptomatology, to examine whether this has a greater effect on far transfer outcomes. Furthermore, it may also be useful to employ new technologies, such as mobile applications and VR, to examine whether this produces larger effects on symptoms. This endeavour may ultimately lead to the development of cost-effective, and widely disseminable treatment enhancers for people with eating and weight disorders.



## Chapter ten:

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## Appendix:

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### Supplementary materials

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### **Chapter 3: Biased interpretation of ambiguous social scenarios in AN**

#### Sentence completion task data

The following analyses were undertaken to examine whether participants with eating disorders had a negative interpretation bias in comparison to healthy eaters as shown by their first and total completions on the sentence completion task.

#### **Supplementary item 1: First completions**

The frequency of negative interpretations made first on the sentence completion task was greater for participants in the clinical group ( $Mdn = 7$ ,  $IQR = 5-8$ ) than healthy controls ( $Mdn = 3$ ,  $IQR = 2-4$ ),  $U = 154.5$ ,  $p < .001$ ,  $r = .61$ ). The number of first neutral interpretations made was lower in patients ( $Mdn = 3$ ,  $IQR = 2-4$ ) than controls ( $Mdn = 5$ ,  $IQR = 4.7-7$ ,  $U = 188$ ,  $p < .001$ ,  $r = .56$ ). Similarly, the number of first positive interpretations made was lower in participants with anorexia nervosa ( $Mdn = < .0001$ ,  $IQR = < .0001-1$ ) than controls ( $Mdn = 1.5$ ,  $IQR = 1-2$ ),  $U = 208.5$ ,  $p < .001$ ,  $r = .55$ ).

#### **Supplementary item 2: Total completions**

The total number of sentences generated on the sentence completion task was greater for participants with anorexia nervosa ( $Mdn = 28$ ,  $IQR = 20-39$ ) than healthy controls ( $Mdn = 22$ ,  $IQR = 14.7-28$ ),  $U = 355$ ,  $p = .025$ ,  $r = .28$ ). The total number of negative interpretations made on the sentence completion task was also greater for

patients ( $Mdn = 18$ ,  $IQR = 12-23$ ) than HCs ( $Mdn = 6.5$ ,  $IQR = 3.7-11$ ),  $U = 122$ ,  $p < .001$ ,  $r = .66$ ). There was no significant difference in the total number of neutral interpretations made between groups (Patients  $Mdn = 10$ ,  $IQR = 6-16$ ; Healthy Controls:  $Mdn = 11.5$ ,  $IQR = 7.7-15.7$ ;  $U = 445.5$ ,  $p = .294$ ,  $r = .13$ ). The total number of positive interpretations made was lower in patients ( $Mdn = 2$ ,  $IQR = <.0001-2$ ) than controls ( $Mdn = 4$ ,  $IQR = 2-5$ ),  $U = 242$ ,  $p < .001$ ,  $r = .47$ ).

## **Chapter 4: Modifying a negative interpretation bias for social stimuli in women with AN**

### **Supplementary item 1: Additional information for the sentence completion task data analysis**

There was no significant interaction between training condition and time ( $X^2(1) = .08$ ,  $p = .77$ ) or between training condition, time and valence ( $X^2(1) = 1.23$ ,  $p = .268$ ) or between patient group, training condition, time point and valence ( $X^2(1) = 2.35$ ,  $p = .1251$ ). There was a significant interaction between training condition and valence ( $X^2(1) = 32.36$ ,  $p = .0262$ ). However, subsequent, pairwise comparisons

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### **Salivary cortisol (stress) levels**

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showed that there was no significant difference in the number of negative ( $Z = -1.35$ ,  $p = .176$ ), or benign ( $Z = 1.7$ ,  $p = .088$ ), ‘best’ interpretations made between the experimental and control condition overall.

### **Supplementary item 2: Additional information for the salivary cortisol levels analysis**

	<b>Experimental</b>			<b>Control</b>		
	Time one	Time two	Time three	Time one	Time two	Time three
<b>Inpatient women</b>	4.92 (2.63)	5.43 (2.73)	5.33 (2.56)	5.12 (1.74)	5.18 (1.92)	4.83 (1.89)
<b>Community women</b>	7.29 (3.76)	7.63 (4.03)	7.12 (4.86)	8.49 (5.33)	7.69 (5.89)	7.3 (5.12)
<b>All participants</b>	6.15 (3.45)	6.59 (3.62)	6.28 (4.01)	6.87 (4.34)	6.49 (4.39)	6.13 (4.1)

This supplementary table shows participants mean salivary cortisol levels per training condition.

## **Chapter 5: Cognitive bias modification for negative interpretations of social stimuli in adolescents with AN**

### **Supplementary item 1: An analysis of the outcome data for only participants with accuracy levels over 80% on the comprehension trials.**

Only 4 participants scored over 90% on the comprehension trials in both CBM-I training conditions, therefore, a cut-off of 80% was used. With this limit a total of 12 participants were included in the following analyses:

#### Responses on the catch trials

Participants made significantly more benign responses to the catch trials in the experimental versus control condition ( $Z = 2.643$ ,  $p = .008$ ,  $r = .54$ ).

#### Sentence completion task

##### *'Best' interpretations on the sentence completion task*

Post experimental training participants made significantly fewer negative interpretations than pre ( $Z = 2.547, p = .011, r = .52$ ). They also made significantly more benign interpretations post training than pre ( $Z = 2.754, p = .006, r = .56$ ).

Post control training there were no significant differences for negative ( $Z = .780, p = .435, r = .16$ ) or benign interpretations compared to pre training ( $Z = .780, p = .435, r = .16$ ).

#### Need threat scale

There was no significant difference in self-esteem levels ( $Z = 1.123, p = .261, r = .23$ ) or meaningful existence ( $Z = .395, p = .693, r = .08$ ) between the experimental versus control condition.

These results mirrored those of the primary analysis within the paper, albeit with slightly larger effect sizes for the sentence completion task and catch trial data.

### **Chapter eight: To go or not to go: A proof of concept study testing food-specific inhibition training for women with eating and weight disorders**

#### **Supplementary item 1: Additional information on the go/ no-go training task procedure**

In the food-specific inhibition training condition, 18 pictures of food items and 18 non-food items were presented to participants either on the left- or right-hand side of the rectangle (each stimulus was presented for 1250ms and followed by an interval of 1250ms before the next stimulus was presented). In total there were 54 no-go signals for the high-calorie food items (100% no-go) presented during the food-specific inhibition training condition and 54 go signals for the low-calorie foods (100% go). The 18 non-food items were used as filler items and included items of clothing. These items were paired with no-go signals for 50% of the trials. These were

included to help to prevent obvious 'good' versus 'bad' food distinctions being noticed explicitly and to reduce demand characteristics.

Nutritional information					
Food item	Brand	Training signal	kCals (per 100g)	Fat (per 100g)	Weight (grams) given in the taste test
Chocolate pieces	Cadburys® 'Bitsa Wispa'	No-go cue	550	34	90
Crisps	Walkers®	No-go cue	526	31.9	25
Grapes	Morrisons® seedless green grapes	Go cue	66	0.1	129
Rice cakes	Boots® organic white rice cakes	Go cue	362	1.4	19
Flapjack bites	Morrisons cake shop®	Novelty exemplar item	488	23	100
Cake bites	Mr Kipling® Chocolate slices (cut into smaller bite size pieces)	Novelty exemplar item	412	18.4	52

**Supplementary item 2:** This table shows the nutritional information for the food items presented to participants in the taste test

## **Supplementary item 2 continued: Additional information on the taste test procedure**

The different portion sizes were chosen so that the food items appeared similar in size when presented on white paper plates; these were placed on a table in a randomised order. A glass of cold water was also offered to participants alongside the food items.

Accompanying the food items was a questionnaire that asked participants to rate the taste of the different foods including VASs and open-ended questions. Two different versions of the taste test questionnaire were used, with one given per session. These questionnaires differed in the order of the questions and were matched in regards to the number and types of questions. Furthermore, the order that participants completed the two taste test questionnaires in was counterbalanced across sessions.

Participants were told that they could taste as much of the food items as they like to rate how they taste, as any leftover food would be disposed of following the session. A 20-minute time frame was given to taste the different food items, complete the taste test questionnaire and additional filler personality questionnaires (i.e., the Temperament and Character Inventory-Revised, Cloninger (1999) and the Personality Belief Questionnaire, Beck & Beck (1991)). These filler personality questionnaires were chosen due to their non-emotional/ non-distressing nature. Participants were alone for the taste test procedure.

## **Supplementary item 3: Additional information relating to the training fidelity analyses**

### *Go/ no-go training task*

#### Training fidelity

In order to examine whether the food-specific training was improving participants' ability to inhibit their response towards high-calorie foods specifically,

an analysis of the no-go food versus no-go filler item trials was performed (as in Lawrence et al., 2015a). This is because the high-calorie foods were always paired with a no-go signal in the food-specific inhibition training condition whereas no-go signals were only paired with the filler items for 50% of these trials. A series of Mann-Whitney U tests showed that the lean comparison women ( $p = .023$ ), BN ( $p = .046$ ), BED ( $p < .001$ ) and overweight women ( $p < .001$ ) made significantly less no-go errors to the high-calorie no-go food versus the 50:50 non-food filler images in the food-specific inhibition training condition. This showed that participants learnt to inhibit the critical training trials (i.e., the food stimuli) more accurately than the filler images.

A 4x2x2 mixed effects linear model (i.e., group x training condition x stimulus category) for reaction times showed that there was a significant main effect of stimulus category type ( $X^2(1) = 10.52, p = .001$ ). Subsequent pairwise comparisons showed that participants had faster reaction times ( $M = 532.97, SD = 100.31$ ) for the 100% go trained food (or control equivalent) relative to the 50:50 trained filler images ( $M = 547.8, SD = 102.8, Z = -3.24, p = .001$ ). There was not a significant interaction between group and stimulus category ( $X^2(3) = .64, p = .89$ ), between training condition and stimulus type ( $X^2(1) = .06, p = .81$ ), or between group, training condition and stimulus category ( $X^2(3) = 1.89, p = 1.89$ ).

### Overall training task results

Wilcoxon signed-rank tests showed that there were no significant within subject differences for overall no-go or go errors between the food-specific and general inhibition training conditions across groups (all  $p > .05$ ).

A 4x2x2 mixed effects linear model (i.e., group x training condition x session) showed that there was a significant main effect of group on participants' reaction times to the go signals on the training task ( $X^2(3) = 20.93, p < .001$ ). Subsequent pairwise comparisons showed that participants with BN had longer reaction times overall than the lean comparison women ( $Z = 2.77, p = .006$ ). A trend was also



indicated for longer reaction times for participants with BED than BN ( $Z = 1.95, p = .051$ ).

A significant interaction between group, training condition and session was found ( $X^2(3) = 8.23, p = .041$ ). Subsequent pairwise comparisons revealed that participants with BED had slower reaction times than those with BN for the general inhibition training in session one ( $Z = 2.92, p = .003$ ). Furthermore, overweight women had slower reaction times in the general inhibition training task than the food-specific inhibition training task in session two ( $Z = -2.42, p = .015$ ).

	Objective binge			Subjective binge			Purge		
Group	Baseline	Experimental	Control	Baseline	Experimental	Control	Baseline	Experimental	Control
Lean comparison women	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BN	2/27	0/23	1/21	10/27	5/23	4/21	2/27	1/23	1/21
Overweight women	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BED	0/17	0/15	0/15	5/17	1/15	2/15	N/A	N/A	N/A

**Supplementary item 4:** This table shows the proportion of participants that experienced objective/ subjective binge-eating episodes, and purging episodes at baseline and post-training. Objective binge-eating episodes were based upon DSM-5 criteria (i.e., consuming an excessive amount of calories (1000, kcal plus) within a discrete time period (2-hours)). The participants placed an asterix next to food items that they felt a loss of control over when eating (i.e., subjective binge-eating episodes).

## **Supplementary item 5: Additional information relating to the taste test analyses for memory and order effects**

### Taste test: session effects

These tests were performed to examine whether the amount of food consumed in session one correlated with food intake in session two. Overall (for all participants) the amount of no-go trained foods ( $r = .617, p < .0001$ ), go trained foods ( $r = .898, p < .0001$ ) and the amount of novelty exemplar item food ( $r = .37, p < .0001$ ) consumed in session one was significantly correlated with the amount consumed in session two.

### Lean comparison women

The amount of no-go trained foods ( $r = .512, p = .009$ ), go trained foods ( $r = .91, p < .001$ ) and the amount of novelty exemplar item food ( $r = .45, p = .024$ ) consumed in session one was significantly correlated with the amount consumed in session two.

### Women with BN

The amount of no-go trained foods ( $r = .72, p < .001$ ), go trained foods ( $r = .91, p < .001$ ) consumed in session one significantly correlated with the amount consumed in session two. There was not a significant correlation between the amount of flapjack bites consumed in session with the amount of cake bites consumed in session two ( $r = .18, p = .357$ ).

### Overweight women

The amount of go foods consumed in session one significantly correlated with the amount consumed in session two ( $r = .8, p < .001$ ). The total of no-go trained foods ( $r = .45, p = .074$ ) and novelty item food ( $r = .3, p = .242$ ) consumed in session one did not significantly correlate with the amount consumed in session two.

### Women with BED

The total of no-go trained foods ( $r = .54, p = .025$ ), go trained foods ( $r = .95, p < .001$ ) and novelty item food ( $r = .57, p = .018$ ) consumed in session one significantly correlated with the amount consumed in session two.

### Taste test: order effects

Paired t-tests showed significantly more no-go trained foods consumed in session 2 ( $M = 200.68$ ,  $SD = 138.42$ ) relative to session 1 ( $M = 167.02$ ,  $SD = 128.11$ ;  $t = 2.67$ ,  $p = .009$ ), no difference for go food consumption (session 2:  $M = 60.6$ ,  $SD = 39.83$ , session 1:  $M = 60.94$ ,  $SD = 37.47$ ;  $t = .18$ ,  $p = .868$ ) and significantly fewer calories for the novelty exemplar food items consumed (session 2:  $M = 98.64$ ,  $SD = 64.88$ , session 1:  $M = 149.47$ ,  $SD = 104.37$ ;  $t = -4.69$ ,  $p < .001$ ).

Levels of high calorie/ low calorie food cravings at baseline of either the active or control condition did not correlate with the amount of no-go trained (i.e., high-calorie) or go trained foods (i.e., low-calorie) consumed in the respective taste test across all of the participant groups (all  $p > .05$ ).

## Appendix:

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### Study materials

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### **Studies one, two and three: overview of key materials**

The following section of the appendix contains examples of the key materials used across studies one, two, and three. This supplements information included within the corresponding chapters of the thesis.

**Participant ID:**

## **DEMOGRAPHIC QUESTIONNAIRE**

The information that you give us on this sheet will be treated as strictly confidential.

Your contact details on this sheet will be kept separate from the responses you provide in the following questionnaire. Only the lead researcher will have access to the file that links your identification details with the following questionnaire.

Thank you for participating in this study.

**Name:**

**Address:**

**Postcode:**

**Tel (home): Mobile:**

**Email:**

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### **YOUR DETAILS**

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**Today's Date:**

**Date of birth:**   **Age:**   **Sex:**   ☐ Male                      ☐ Female

**Is English your first language?**              Yes / No

**What is your ethnicity?**

- ☐ **White British**
- ☐ **White Irish**
- ☐ **Other White**
- ☐ **Mixed White and Black Caribbean**
- ☐ **Mixed White and Black African**
- ☐ **Mixed White and Asian**
- ☐ **Other Mixed**
- ☐ **Asian or Asian British – Indian**
- ☐ **Asian or Asian British – Pakistani**
- ☐ **Asian or Asian British – Bangladeshi**
- ☐ **Other Asian**
- ☐ **Black or Black British – Caribbean**
- ☐ **Black or Black British – African**
- ☐ **Other Black**
- ☐ **Chinese**
- ☐ **Other ethnic group-\_\_\_\_\_**

**Are you currently receiving any medication?**              Yes /\_No

If yes, please give details .....

**Have you ever been diagnosed with a visual impairment?** Yes / No

If yes, is this corrected with an aide? (e.g. glasses, contact lenses) Yes / No

**Have you ever been diagnosed with a neurological condition?** Yes / No

If yes, please give details.....

**What is your current employment status?**

- |                                     |  |
|-------------------------------------|--|
| <input type="checkbox"/> Full time  | <input type="checkbox"/> Retired                     |
| <input type="checkbox"/> Part time  | <input type="checkbox"/> Sick leave                  |
| <input type="checkbox"/> Unemployed | <input type="checkbox"/> House wife / husband        |
| <input type="checkbox"/> Student    | <input type="checkbox"/> Other .....(please specify) |

**What is your current or most recent occupation?**

**If you are unemployed, please indicate for how long you have been unemployed for and what your previous occupation was:**

Unemployed for: .....

Previous occupation: .....

**What is the highest level of education you completed?**

- |  |   |
|--|---|
| <input type="checkbox"/> No qualifications | <input type="checkbox"/> University Degree          |
| <input type="checkbox"/> O Level / GCSE    | <input type="checkbox"/> Postgraduate Degree        |
| <input type="checkbox"/> A Level / NVQ     | <input type="checkbox"/> Other.....(please specify) |
| <input type="checkbox"/> Diploma / BTEC    |   |

**How many years of education have you received?**

**Have you had to take time off from school or work due to your eating difficulties?**

Yes / No

If Yes, how long in total? .....

**Have you had a previous hospital admission for your condition? Yes/No**

If so, how many? .....

**For how many years have you had an eating disorder? .....**

**What is the lowest ever BMI you have been? .....**

**What is the highest ever BMI you have been? .....**



**What is your marital status?**

- |  |                                    |
|--|------------------------------------|
| <input type="checkbox"/> Married           | <input type="checkbox"/> Divorced  |
| <input type="checkbox"/> Living together   | <input type="checkbox"/> Separated |
| <input type="checkbox"/> Single            | <input type="checkbox"/> Widowed   |
| <input type="checkbox"/> In a relationship |                                    |

**How many children do you have?**

- |                      |   |
|----------------------|---|
| a) No. of daughters: | b) their ages: ____; ____; ____; ____; ____ |
| c) No. of sons:      | d) their ages: ____; ____; ____; ____; ____ |

**Who lives in your household with you?** (e.g. mum, brother, 2 friends)

**Has anyone in your family been diagnosed with a psychiatric condition?** Yes / No

If yes, please give details

What relation is this person to you?

**Have you ever been diagnosed with a mental illness?** (Yes / No)

If yes, please give details (e.g., the diagnosis, if it's current, any co-morbidities)

.....

**What is your current weight?**

**What is your current height?**

## EATING QUESTIONNAIRE

Questions 13-18: Please fill in the appropriate number in the boxes on the right. Remember that the questions only refer to the past four weeks (28 days).

Over the past four weeks (28 days) .....

13 Over the past 28 days, how many <u>times</u> have you eaten what other people would regard as an <u>unusually large amount of food</u> (given the circumstances)?	.....
14 ..... On how many of these times did you have a sense of having lost control over your eating (at the time that you were eating)?	.....
15 Over the past 28 days, on how many <u>DAYS</u> have such episodes of overeating occurred (i.e., you have eaten an unusually large amount of food <u>and</u> have had a sense of loss of control at the time)?	.....
16 Over the past 28 days, how many <u>times</u> have you made yourself sick (vomit) as a means of controlling your shape or weight?	.....
17 Over the past 28 days, how many <u>times</u> have you taken laxatives as a means of controlling your shape or weight?	.....
18 Over the past 28 days, how many <u>times</u> have you exercised in a "driven" or "compulsive" way as a means of controlling your weight, shape or amount of fat, or to burn off calories?	.....

Questions 19 to 21: Please circle the appropriate number. Please note that for these questions the term "binge eating" means eating what others would regard as an unusually large amount of food for the circumstances, accompanied by a sense of having lost control over eating.

19 Over the past 28 days, on how many days have you eaten in secret (ie, furtively)? ..... Do not count episodes of binge eating	No	1-5	6-12	13-15	16-22	23-27	Every
	days	days	days	days	days	days	day
	0	1	2	3	4	5	6
20 On what proportion of the times that you have eaten have you felt guilty (felt that you've done wrong) because of its effect on your shape or weight? ..... Do not count episodes of binge eating	None	A few	Less	Half of	More	Most	Every
	of the	of the	than	the	than	of the	time
	times	times	half	times	half	time	time
	0	1	2	3	4	5	6
21 Over the past 28 days, how concerned have you been about other people seeing you eat? ..... Do not count episodes of binge eating	Not at all	Slightly		Moderately		Markedly	
	0	1	2	3	4	5	6

Questions 22 to 28: Please circle the appropriate number on the right. Remember that the questions only refer to the past four weeks (28 days).

Over the past 28 days .....	Not at all		Slightly		Moderately		Markedly
22 Has your <u>weight</u> influenced how you think about (judge) yourself as a person?	0	1	2	3	4	5	6
23 Has your <u>shape</u> influenced how you think about (judge) yourself as a person?	0	1	2	3	4	5	6
24 How much would it have upset you if you had been asked to weigh yourself once a week (no more, or less, often) for the next four weeks?	0	1	2	3	4	5	6
25 How dissatisfied have you been with your <u>weight</u> ?	0	1	2	3	4	5	6
26 How dissatisfied have you been with your <u>shape</u> ?	0	1	2	3	4	5	6
27 How uncomfortable have you felt seeing your body (for example, seeing your shape in the mirror, in a shop window reflection, while undressing or taking a bath or shower)?	0	1	2	3	4	5	6
28 How uncomfortable have you felt about <u>others</u> seeing your shape or figure (for example, in communal changing rooms, when swimming, or wearing tight clothes)?	0	1	2	3	4	5	6

What is your weight at present? (Please give your best estimate.) .....

What is your height? (Please give your best estimate.) .....

If female: Over the past three-to-four months have you missed any menstrual periods? .....

If so, how many? .....

Have you been taking the "pill"? .....

**THANK YOU**

# DASS<sub>21</sub>

Name:

Date:

Please read each statement and circle a number 0, 1, 2 or 3 which indicates how much the statement applied to you *over the past week*. There are no right or wrong answers. Do not spend too much time on any statement.

*The rating scale is as follows:*

- 0 Did not apply to me at all
- 1 Applied to me to some degree, or some of the time
- 2 Applied to me to a considerable degree, or a good part of time
- 3 Applied to me very much, or most of the time

1	I found it hard to wind down	0	1	2	3
2	I was aware of dryness of my mouth	0	1	2	3
3	I couldn't seem to experience any positive feeling at all	0	1	2	3
4	I experienced breathing difficulty (eg, excessively rapid breathing, breathlessness in the absence of physical exertion)	0	1	2	3
5	I found it difficult to work up the initiative to do things	0	1	2	3
6	I tended to over-react to situations	0	1	2	3
7	I experienced trembling (eg, in the hands)	0	1	2	3
8	I felt that I was using a lot of nervous energy	0	1	2	3
9	I was worried about situations in which I might panic and make a fool of myself	0	1	2	3
10	I felt that I had nothing to look forward to	0	1	2	3
11	I found myself getting agitated	0	1	2	3
12	I found it difficult to relax	0	1	2	3
13	I felt down-hearted and blue	0	1	2	3
14	I was intolerant of anything that kept me from getting on with what I was doing	0	1	2	3
15	I felt I was close to panic	0	1	2	3
16	I was unable to become enthusiastic about anything	0	1	2	3
17	I felt I wasn't worth much as a person	0	1	2	3
18	I felt that I was rather touchy	0	1	2	3
19	I was aware of the action of my heart in the absence of physical exertion (eg, sense of heart rate increase, heart missing a beat)	0	1	2	3
20	I felt scared without any good reason	0	1	2	3
21	I felt that life was meaningless	0	1	2	3

## ASRS-Q

The items below describe situations in which people sometimes ask things of others.  
For each item, imagine that you are in the situation, and then answer the question that follows it.

**1. You ask your parents or another family member for a loan to help you through a difficult financial time.**

How concerned or anxious would you be over whether or not your family would want to help you?

Very unconcerned 1 2 3 4 5 very concerned 6

I would expect that they would agree to help as much as they can

Very unlikely 1 2 3 4 5 very likely 6

---

**2. You approach a close friend to talk after doing or saying something that seriously upset him/her.**

How concerned or anxious would you be over whether or not your friend would want to talk with you?

Very unconcerned 1 2 3 4 5 very concerned 6

I would expect that that he/she would want to talk with me to try to work things out

Very unlikely 1 2 3 4 5 very likely 6

---

**3. You bring up the issue of sexual protection with your significant other and tell him/her how important you think it is.**

How concerned or anxious would you be over his/her reaction?

Very unconcerned 1 2 3 4 5 very concerned 6

I would expect that that he/she would be willing to discuss our possible options without getting defensive

Very unlikely 1 2 3 4 5 very likely 6

---

**4. You ask your supervisor for help with a problem you have been having at work.**

How concerned or anxious would you be over whether or not the person would want to help you?

Very unconcerned 1 2 3 4 5 very concerned 6

I would expect that that he/she would want to try to help out

Very unlikely 1 2 3 4 5 very likely 6

---

**5. After a bitter argument, you call or approach your significant other because you want to make up**

How concerned or anxious would you be over whether or not your significant other would want to make up with you?

Very unconcerned 1 2 3 4 5 very concerned 6

I would expect that that he/she would be at least as eager to make up as I would be

Very unlikely 1 2 3 4 5 very likely 6

---

**6. You ask your parents or other family members to come to an occasion important for you.**

How concerned or anxious would you be over whether or not they would want to come?

Very unconcerned 1 2 3 4 5 very concerned 6

I would expect that that they would want to come

Very unlikely 1 2 3 4 5 very likely 6

---

**7. At a party, you notice someone on the other side of the room that you'd like to get to know, and you approach him/her to try to start a conversation.**

How concerned or anxious would you be over whether or not the person would want to talk with you?

Very unconcerned 1 2 3 4 5 very concerned 6

I would expect that he/she would want to talk with me

Very unlikely 2 3 4 5 very likely 6 1

---

**8. Lately you've been noticing some distance between yourself and your significant other, and you ask him/her if there is something wrong**

How concerned or anxious would you be over whether or not he/she still loves you and wants to be with you?

Very unconcerned 1 2 3 4 5 very concerned 6

I would expect that he/she will show sincere love and commitment to our relationship no matter what else may be going on

Very unlikely 1 2 3 4 5 very likely 6

---

**9. You call a friend when there is something on your mind that you feel you really need to talk about.**

How concerned or anxious would you be over whether or not your friend would want to listen?

Very unconcerned

very concerned

1

2

3

4

5

6

I would expect that he/she would listen and support me

Very unlikely

very likely

1

2

3

4

5

6

---

## Work and Social Adjustment Scale

Please rate each of the following questions on a 0 to 8 scale:

**0 indicates no impairment at all and  
8 indicates very severe impairment.**

*If you are not currently experiencing any physical or mental health problems, please  
answer the questions anyway.*

1. Because of my disorder, my ability to work is impaired. 0 means not at all impaired and 8 means very severely impaired to the point that I cannot work.  
(please circle)

0      1      2      3      4      5      6      7      8

2. Because of my disorder, my home management (cleaning, tidying, shopping, cooking, looking after home or children, paying bills) is impaired. 0 means not at all impaired and 8 means very severely impaired.

0      1      2      3      4      5      6      7      8

3. Because of my disorder, my social leisure activities (with other people, such as parties, bars, clubs, outings, visits, dating, and home entertainment) are impaired. 0 means not at all impaired and 8 means very severely impaired.

0      1      2      3      4      5      6      7      8

4. Because of my disorder, my private leisure activities (done alone, such as reading, gardening, collecting, sewing, walking alone) are impaired. 0 means not at all impaired and 8 means very severely impaired.

0      1      2      3      4      5      6      7      8

5. Because of my disorder, my ability to form and maintain close relationships with others, including those I live with, is impaired. 0 means not at all impaired and 8 means very severely impaired.

0      1      2      3      4      5      6      7      8



## The Sentence Completion Task

Please write down as many short completions to a given sentence as you can, in the order they come to mind.

Use one to three words for each completion

Indicate with an asterix\* the completion you think best completes the sentence

1 (Practice)	7
2 (Practice)	8
3	9
4	10
5	11
6	12

## Sentence completion task

### Examples of stem-sentences used in studies one, two and three

1. As you finish your performance you see that the audience thinks you are...
2. As you give a speech, you see a person in the crowd smiling, which means that your speech is...
3. Your friend declines an invitation to go out with you because of...
4. Your supervisor calls you into the office to discuss your...
5. Your friend does not show up to meet you because you are...
6. As you walk into a group of people, they stop talking because they were talking about...
7. You are unable to finish your work on time, so your supervisor feels that you are...
8. As you walk into the party nobody notices you because you are...
9. When you talk to people, they listen to what you are saying and look at you...
10. Some acquaintances do not greet you on the street because you are...
11. When you ask friends for a ride from the airport, they think that you are...
12. As you speak to the person standing next to you, they look at you in a way that suggests that you are...

#### **Study four: overview of key materials**

The following section of the appendix contains examples of the key materials used in study four. This supplements information included within chapter eight of the thesis and in the previous section of the appendix.

Gender: M   F (circle one)

## FCQ-T

Below is a list of comments made by people about their eating habits. In the space to the left, please write the letter indicating how frequently these comments would be true for you in general. Please respond to each item as honestly as possible.

Never or  
Not applicable

Rarely

Sometimes

Often

## Usually Always

(1)

(2)

(3)

(4)

(5)

(6)

\_\_\_\_\_ 29. If I give in to a food craving, all control is lost.

\_\_\_\_\_ 30. When I'm stressed out, I crave food.

\_\_\_\_\_ 31. I daydream about food.

\_\_\_\_\_ 32. Whenever I have a food craving, I keep on thinking about eating until I actually eat the food.

\_\_\_\_ 33. If I am craving something, thoughts of eating it consume me.

\_\_\_\_\_ 34. My emotions often make me want to eat.

\_\_\_\_\_ 35. Whenever I go to a buffet I end up eating more than what I needed.

\_\_\_\_\_ 36. It is hard for me to resist the temptation to eat appetizing foods that are in my reach.

\_\_\_\_\_ 37. When I am with someone who is overeating, I usually overeat too.

\_\_\_\_\_ 38. When I eat food, I feel comforted.

\_\_\_\_\_ 39. I crave foods when I'm upset.

## **Taste test**

- We would like to know your opinion on the taste of some different food items and ask that you rate the taste of these products by answering the questions below.
- You can taste as much of the products as you want, as we will throw out the food that is left over at the end of this session.
- You will be given 20 minutes to taste the products and to complete the additional personality questionnaires.
- Please relax and take your time as you can always have extra time to finish the questionnaires at the end of the study.

FOOD 1 is: \_\_\_\_\_

1. How do you find the appearance of the food?

2. How do you find the smell of the food?

3. How sweet is the product?

4. How salty is the product?

Please mark the following lines at the points that most accurately reflect the way that you find the **FOOD 1** in front of you.

Urge to eat:

Would not  
wish to eat it  
at all

\_\_\_\_\_

Would like to  
eat some  
very much  
indeed

FOOD 2 is: \_\_\_\_\_

1. How do you find the appearance of the food?

2. How do you find the smell of the food?

3. How sweet is the product?

4. How salty is the product?

Please mark the following lines at the points that most accurately reflect the way that you find the **FOOD 2** in front of you.

**Urge to eat:**

Would not  
wish to eat it  
at all

\_\_\_\_\_

Would like to  
eat some  
very much  
indeed



FOOD 3 is: \_\_\_\_\_

1. How do you find the appearance of the food?

2. How do you find the smell of the food?

3. How sweet is the product?

4. How salty is the product?

Please mark the following lines at the points that most accurately reflect the way that you find the **FOOD 3** in front of you.

**Urge to eat:**

Would not  
wish to eat it  
at all

\_\_\_\_\_

Would like to  
eat some  
very much  
indeed

FOOD 4 is: \_\_\_\_\_

1. How do you find the appearance of the food?

2. How do you find the smell of the food?

3. How sweet is the product?

4. How salty is the product?

Please mark the following lines at the points that most accurately reflect the way that you find the **FOOD 4** in front of you.

**Urge to eat:**

Would not  
wish to eat it  
at all

\_\_\_\_\_

Would like to  
eat some  
very much  
indeed

FOOD 5 is: \_\_\_\_\_

1. How do you find the appearance of the food?

2. How do you find the smell of the food?

3. How sweet is the product?

4. How salty is the product?

Please mark the following lines at the points that most accurately reflect the way that you find the **FOOD 5** in front of you.

**Urge to eat:**

Would not  
wish to eat it  
at all

\_\_\_\_\_

Would like to  
eat some  
very much  
indeed

General

**Which product do you find the most palatable? Give each product a point on a scale ranging from 1 to 10 (1 = not at all palatable, 10 = very palatable).**

**Food item one**

1      2      3      4      5      6      7      8      9      10

**Food item two**

1      2      3      4      5      6      7      8      9      10

**Food item three**

1      2      3      4      5      6      7      8      9      10

**Food item four**

1      2      3      4      5      6      7      8      9      10

**Food item five**

1      2      3      4      5      6      7      8      9      10

**Feedback on the go/ no go training**

1. Please rate **how much you enjoyed the training from 0 (Not at All) to 10 (Extremely enjoyed it).**
  
2. Please rate **how much effort you had to put into the training from 0 (No effort at all) to 10 (Extreme amounts of effort).**
  
3. Please rate **how frustrated you felt completing the training from 0 (not frustrated at all) to 10 (extremely frustrated)**
  
4. Please rate **how difficult you found it to concentrate on the training from 0 (not difficult at all) to 10 (extremely difficult)**
  
5. Would you be willing to continue to use this kind of computer training?

Yes/ No

If No, why not?

.....

.....

.....

6. Any further comments:

.....

.....

.....